PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report, contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
27 April 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

1995 0120 044

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CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 MARCH 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$6,219.58	$4,573.71	$1,645.87	$6,219.58	$4,573.71	$1,645.87
TRAVEL	$80.00	$80.00	$0.00	$80.00	$80.00	$0.00
OTHER DIRECT COSTS	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
INDIRECT COSTS	$3,086.80	$2,280.32	$806.48	$3,086.80	$2,280.32	$806.48
TOTAL EXPENDITURES	$9,386.38	$6,934.03	$2,452.35	$9,386.38	$6,934.03	$2,452.35

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS						
SMART	22.00	11.00	11.00	22.00	11.00	11.00
KLASKY	192.00	192.00	0.00	192.00	192.00	0.00
PROVOST	16.00	16.00	0.00	16.00	16.00	0.00
LISLE	60.00	0.00	60.00	60.00	0.00	60.00
LI	57.00	0.00	57.00	57.00	0.00	57.00
TOTAL LABOR HOURS	347.00	219.00	128.00	347.00	219.00	128.00

Monthly Report: March 1990

VSL Staff: Ron Klasky

GRA Support: Micheline Provost, Brian Blau

Milestones

- Develop software to read and extract polygons from SIMNET Plan View Database
- Modify Li's software to drive car over SIMNET patch on SG Iris

Accomplishments

Without the use of S-1000, the BBN database editing tool, a BBN SIMNET database was successfully read from the SIMNET MCC Masscomp into a Silicon Graphics Iris Workstation. A patch of terrain was displayed and a computer generated car was driven over the terrain.

Discussions were held with sponsors, colleagues, and graduate students on the research approach, design, and implementation of automatic feature extraction algorithms. Drs. Shah (UCF) and Bowyer (USF) will begin research 1 May 90.

The public domain image processing toolkit from U of Waterloo was successfully installed into the SG Iris.

Problems

The database which was ported to the SG Iris was a Plan View database, as opposed to the CIG database, which contains the color and texture information and is loaded on the image generator. Without the <u>file format of the CIG database</u>, it cannot be changed. A

verbal request was made to Col. Szymanski (3/19/90) to obtain the CIG database file format (and also S-1000).

Additonal contact with NTSC was made by Doug Wood contacting Julie Cameron for the CIG database file format (3/30/90).

Project Monthly Report - March 1990
Multiple Image Generator Databases
Principal Investigator: Michael Moshell

Milestones

- Acquire E&S Tools
- Acquire S-1000 Tools
- Design the MIDB Tool Suite

Accomplishments

(1) On 22 March, during a visit to NASA-Ames, Dr. Moshell visited Software Systems in San Jose. Software Systems produces MULTI-GEN, which is the only generic database development tool for image generators currently on the market. MultiGen produces as its output a generic file format titled *Flight*,, which is then translated into the specific database format of various IG's by formatter programs.

Software Systems' president Dennis Yeo offered to donate an installation of the software (worth $24,000) to IST on the condition that we receive permission, in writing, from Evans & Sutherland to construct a formatter from Flight format to ESIG-500 format, and that we place this software in the public domain.

(2) Dr. Moshell immediately wrote a memo to Mike Hassom and Jim Bleak at E&S, requesting permission to do same, since the development of such a formatter was in any case already part of our funded work under the present Task of the BAA.

(3) Xin Li, Curtis Lisle and Jinxiong Chen have continued to learn the operations of the ESIG-500 image generator and its database formats. A non-paid volunteer, Dr. Kate Kinsley from UCF Computer Science, has also been reading the manuals and familiarizing herself with the system in anticipation of working with us in a learning mode on the MIDB task. Dr. Kinsley gave a colloquium talk on 12 March as part of the weekly VSL staff meeting on the subject of the ESIG's database format.

Problems

(1) E&S tools' order is presently ready to ship at Salt Lake City, pending agreement between E&S' lawyers and UCF's lawyers on the terms of the license agreement. A standard exclusion in Florida law is that the state is unwilling to "indemnify and hold harmless" a software vendor, which is a clause that often turns up in license agreements. E&S must now accept this rather minor change to the license agreement.

(2) The SIMNET S-1000 tools, which are supposed to come to us via ETL, are still unavailable although an E-Mail message from George Lukes indicated that they would, at last, be forthcoming.

(3) Delays in receiving the present cycle of IQC funding have in turn prevented a necessary maintenance call for the ESIG, which is having some microcode problems. Curt Lisle believes that the problem is an update of the microcode which was shipped to us to modify the scan rate from 50 hz to 60 hz, and he is attempting to restore the 50 hz microcode to verify that this new code is buggy.

If this measure does not restore the ESIG's operation, then a paid E&S service call will be necessary.

PREPARED FOR:

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ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report, contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
25 May 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 APRIL 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$12,576.46	$9,394.48	$3,181.98	$6,356.88	$4,820.77	$1,536.11
TRAVEL	$115.00	$115.00	$0.00	$35.00	$35.00	$0.00
OTHER DIRECT COSTS	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
INDIRECT COSTS	$3,086.80	$2,280.32	$806.48	$0.00	$0.00	$0.00
TOTAL EXPENDITURES	$15,778.26	$11,789.80	$3,988.46	$6,391.88	$4,855.77	$1,536.11

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 26 APRIL						
SMART	36.00	17.00	19.00	14.00	6.00	8.00
KLASKY	390.00	390.00	0.00	198.00	198.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	60.00	40.00	20.00	60.00	40.00	20.00
LISLE	136.00	0.00	136.00	76.00	0.00	76.00
LI	97.00	0.00	97.00	40.00	0.00	40.00
TOTAL LABOR HOURS	735.00	463.00	272.00	388.00	244.00	144.00

Monthly Report - April 1990

Geospecific Databases Project

Acting Project Lead: Ron Klasky

Accomplishments

1) Two meetings with Drs. Mubarak Shah (UCF-CS) and Kevin Bowyer (USF-CS, Tampa) were held, in which work plans for the joint research in stereo extraction were made. This work will begin in May 1990. Drs. Shah and Bowyer will select and train the appropriate student employees during April.

Dr. Shah will concentrate his efforts on pixel-level mathematical techniques for extracting features such as edges and regions from video and photographic imagery. Dr. Bowyer's research will focus on taking feature data such as edges and matching them in topological space against *a priori* models such as prismatic (parallelopiped) structures for buildings. Thus, Shah's output serves as Bowyer's input (although they can pursue the research in parallel).

Both components of the team will develop literature searches and collections of existing software for IST staff to use in building the first demonstration database. Subsequent (calendar 1991) demonstrations will be based on a mixture of off the shelf and project-generated algorithms.

2) Photographic imagery was obtained from the Army of Indian Springs AFB; contacts were made with commercial firms in Tampa and other Central Florida locations to locate a simple and reliable vendor-path for imagery scanning. At month's end, this quest continues.

Problems

No major problems. This work begins in earnest in May.

Monthly Report: April 1990

Project Lead: Ron Klasky

Milestones

- Attempted to develop software to read SIMNET CIG Database
- Modify Li's software to manipulate SIMNET terrain with bulldozer
- Received Defense Mapping Agency ITD (Interim Terrain Database) data

Accomplishments

Using the SIMNET Plan View Database, the bulldozer software was ported to dig up SIMNET data using techniques in dynamic terrain and micro terrain.

Work was initiated to read a SIMNET CIG database, again without the use of BBN's S1000 package. Work looked promising at first, but then reached a standstill when the file structure no longer matched the structures defined in the documentation recently made available by BBN to IST.

Work has begun on bringing the DEC VAXstation 3100 up and on the Visual Lab's Ethernet. The 3100 will be home to the Evans & Sutherland Database Modeling Tools once they arrive, which is expected shortly.

Problems

For any further work on BBN SIMNET databases the software package S-1000 must be obtained. If it cannot be obtained than any plans for doing anything with the SIMNET databases, aside from displaying them, should be scrapped.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

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- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
26 June 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 MAY 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$22,481.89	$16,016.95	$6,464.94	$9,905.43	$6,622.47	$3,282.96
TRAVEL	$115.00	$115.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$4.21	$2.11	$2.10	$4.21	$2.11	$2.10
INDIRECT COSTS	$3,086.80	$2,280.32	$806.48	$0.00	$0.00	$0.00
TOTAL EXPENDITURES	$25,687.90	$18,414.38	$7,273.52	$9,909.64	$6,624.58	$3,285.06

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 7 JUNE						
SMART	64.00	31.00	33.00	28.00	14.00	14.00
KLASKY	606.00	606.00	0.00	216.00	216.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	147.00	40.00	107.00	87.00	0.00	87.00
MOSHELL	28.00	26.00	2.00	28.00	26.00	2.00
LISLE	198.50	0.00	198.50	62.50	0.00	62.50
STARK	160.00	160.00	0.00	160.00	160.00	0.00
ROY	67.00	67.00	0.00	67.00	67.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	1383.50	946.00	437.50	648.50	483.00	165.50

Monthly Report - May 1990

Multiple IG Databases Project

Project Lead: Michael Moshell (Acting)

Accomplishments

(1) MultiGen was donated by Software Systems (San Jose, CA) and installed on the Iris workstation. This $38,820 donation materially enhances VSL's capability to develop multiple-IG databases and conduct research into semi-automated correlation technology.

(2) The ESIG tools arrived, and were installed on VAXstation 3100.

PROBLEMS:

A number of difficulties arose with the VAXstation installation of the ESIG tools, relating to the lack of specific system utilities in the proper version to work with the ESIG basic graphic toolset.

The reason for these difficulties is that Evans and Sutherland ordinarily sells the VAXstation along with the tool software; thus, they had the chance at Salt Lake to integrate the software. In the case of VSL, we inherited the VAXstation from the DARPA project.

This cost savings of around $12,000 has, however, resulted in the loss of time and increased effort at getting the ESIG tools in place and working.

Monthly Report - May 1990

Geospecific Databases Project

Project Lead: Ron Klasky (Acting)

Accomplishments

(1) Annotated bibliographies were constructed in the areas of stereo algorithms (SHAH) and shadow extraction (BOWYER), as per the time line. These reports were provided to the sponsors as part of the briefing notes from the 12 June quarterly progress briefing and demonstration.

(2) Task definitions were more sharply focused. Correspondence with David McKeown at Carnegie Mellon established which of his algorithms and images were available for our use.

(3) Specifications were established for the magnetic tape drive for reading DMA data. Upon receipt of the IQC funding, this drive was requisitioned.

PROBLEMS:

None at present.

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
P.O. BOX 25000, ORLANDO, FLORIDA 32816-0054 (305) 281-5155

June 26, 1990

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Greene AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Greene:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the May 1990 time period are forwarded for your review and/or approval.

If you have any questions, please call me at 658-5014 or 658-5000.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

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- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
31 July 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 JUNE 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$30,509.08	$22,212.77	$8,296.31	$8,027.19	$6,195.82	$1,831.37
TRAVEL	$115.00	$115.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$2,510.58	$1,255.29	$1,255.29	$2,506.37	$1,253.18	$1,253.19
INDIRECT COSTS *	$16,235.98	$11,555.70	$4,680.28	$13,149.18	$9,275.38	$3,873.80
TOTAL EXPENDITURES	$49,370.64	$35,138.76	$14,231.88	$23,682.74	$16,724.38	$6,958.36

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 21 JUNE						
SMART	72.00	35.00	37.00	8.00	4.00	4.00
KLASKY	654.00	606.00	48.00	48.00	0.00	48.00
BOWYER *	144.00	144.00	0.00	144.00	144.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	172.00	55.00	117.00	25.00	15.00	10.00
MOSHELL	28.00	26.00	2.00	0.00	0.00	0.00
LISLE	254.00	0.00	254.00	55.50	0.00	55.50
STARK	240.00	240.00	0.00	80.00	80.00	0.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	1744.00	1189.00	555.00	360.50	243.00	117.50

* INCLUDES CORRECTION OF ERROR FROM PREVIOUS PERIOD

Monthly Report - July 1990

Geospecific Databases Project

Project Lead: Ron Klasky (Acting)

Accomplishments

(1) Shah and Bowyer have applied a second stereo matching algorithm to the test datasets they are using (Los Angeles Airport) and are measuring its performance.

(2) Ray Green has provided IST with information about several map products, which include USGS high altitude photo series which can serve as sources of stereo imagery of Indian Springs AFB.

(3) Moshell has discussed with George Lukes the architecture and structure of the TIES workstation system, and its availability, so that Moshell can construct a Materials Requirement in early August for submission to Ray Green. In brief, the results are as follows:

- TIES consists of two pieces: IDS and DSPW.

- Image Digitizing System (IDS) - the high powered scanning system, being built by InterGraph. Will cost around $300,000 per installation.

- Digital Stereo Photographic Workstation (DSPW) - a gussied-up Sun/4 workstation, with special purpose stereo extraction and display boards in it and a lot of software, representing state of the art in ortho photo correction etc. Output will be appropriate for input into ArcInfo. DSPW will cost around $225,000. ArcInfo will cost around $36,000.

DSPW is in factory acceptance now, will be (supposedly) delivered in early September to ETL. IDS will be in test in mid-August, delivered in late September.

George Lukes recommends against our getting IDS, offers to work out a deal to scan images for us when hard copy is involved. I agree; having a $300,000 machine in house for occasional use is not a good investment.

George Lukes gave us the name of the ETL engineer in charge of TIES, so that we can secure more information in pursuit of the development of a formal Materials Requirement.

PROBLEMS: None at the moment.

Monthly Report - July 1990

Multiple IG Databases Project

Project Lead: Michael Moshell (Acting)

Accomplishments

(1) Two Personal Iris computers were received and installed. These machines are to be used for the S-1000 toolkit and the MultiGen toolkit, respectively.

(2) Both toolkits were installed on their proper Iris machines. Larry Brown, who took the S-1000 training course at ETL during July, is now working to get some bugs out of S-1000 which presently prevent its use on the Personal Iris, apparently due to some mismatches between the graphics libraries there and on the 4D70.

Worst case will be that we will have to use the S-1000 tools on the 4D70 workstation. It is better suited for projects requiring its realtime capabilities.

(2) Ron Klasky attended the IMAGES conference, made a number of contacts in the image generator world. While there he negotiated with Software Systems (providers of MultiGen) and IST has now agreed to serve as the repository for all public domain Flight format databases (produced by MultiGen). This increases our access to simulation databases for a variety of purposes.

(3) J. Morie analyzed the data formats from the S-1000 and Flight systems, and is building a matrix of features and capabilities as part of an overall analysis of how the MIDB task should be pursued.

(4) Chen Jinxiong took a one-week course in the VMS operating system from Digital Equipment Corporation, in order to facilitate his work with the ESIG-500's database management suite of software.

(5) Chen Jinxiong extended the Research Park database produced by Ron Klasky, in order to insert specific features and see the resulting data structures in the Flight database. This work is preparatory to building the Flight -> ESIG formatter program.

PROBLEMS: The software provided by Evans & Sutherland continues to malfunction. Klasky and Chen were in daily dialog with E&S through much of July. At present (1 August) Klasky is spending two weeks in Salt Lake City to learn more about how to solve these problems and to take a general course in ESIG database building.

Klasky's travel and his labor are being paid for by DARPA, as part of the collaborative effort to get the ESIG functioning for the DARPA SAF project and the PM-TRADE MIDB project.

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12350 RESEARCH PARKWAY
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BAA 89-01

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Cost and Progress Reports
4 September 1990

Aug

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 JULY 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$44,987.05	$31,490.93	$13,496.12	$14,477.96	$9,278.16	$5,199.81
TRAVEL	$115.00	$115.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$2,510.58	$1,255.29	$1,255.29	$0.00	$0.00	$0.00
INDIRECT COSTS *	$23,330.18	$16,102.00	$7,228.19	$7,094.20	$4,546.30	$2,547.90
TOTAL EXPENDITURES	$70,942.81	$48,963.21	$21,979.59	$21,572.16	$13,824.45	$7,747.71

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 19 JULY						
SMART	95.00	47.00	48.00	23.00	12.00	11.00
KLASKY	654.00	606.00	48.00	0.00	0.00	0.00
MORIE	80.00	0.00	80.00	80.00	0.00	80.00
BOWYER	176.00	176.00	0.00	32.00	32.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	244.00	72.00	172.00	72.00	17.00	55.00
MOSHELL	28.00	26.00	2.00	0.00	0.00	0.00
LISLE	331.00	0.00	331.00	77.00	0.00	77.00
STARK	400.00	400.00	0.00	160.00	160.00	0.00
WATKINS	141.00	66.00	75.00	141.00	66.00	75.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	2329.00	1476.00	853.00	585.00	287.00	298.00

Monthly Report - Aug 1990

Geospecific Databases Project

Project Lead: Brian Blau

Accomplishments

1) New graduate assistant Chuck Campbell, and new Project Manager Brian Blau, worked to build 3d visualization tools on Silicon Graphics which display the disparity maps computed by Shah's stereo algorithms as real 3d perspective images. Demos are now available.

2) Shah, Bowyer, Blau, Campbell, Bowyer's student Maha Sallam and Moshell met on 28 Aug. in Orlando to discuss plans for fall semester. A Florida High Tech proposal is being developed to extend the work on stereo and shadows, to achieve a "force multiplier" with the Federal dollars.

Plans were made for an interactive CAD-style shadow image extraction program to be built during the fall semester by Maha Sallam. We also discussed the needs for realistic imagery for the production of a demo database during the fall of 1990, and considered the parameters for photography.

One thing which Shah and Bowyer have repeatedly mentioned is that table-top imagery (i.e. "point a TV camera at some models") has advantages over real-world imagery in that it's easy to measure precise camera positions and "building" sizes, etc. Should we fly over Ft. Rucker, it's hard to position the cameras precisely in the inverse image transformations necessary to ortho-rectify the imagery.

Chuck Campbell was tasked to become expert on cartographic imagery and to report back on the camera specs needed to get good imagery for stereo reconstruction of our demo database.

3) Maha Sallam and Kevin Bowyer provided an extended version of their earlier survey paper on shadow based methodology (attached).

PROBLEMS: None at the moment.

Monthly Report - August 1990

Multiple IG Databases Project

Project Lead: Michael Moshell (Acting)

Accomplishments

(1) Chen and Klasky have succeeded in getting the ESIG database tools to work, and have constructed a small model of a house with IST on the roof, and installed it into an ESIG database and flown over it.

(2) Jacki Morie has constructed a matrix summarizing the salient features of MultiGen, S-1000 and ESIG databases as a starting point for the design of the formatters necessary to move between the various formats. A copy of that matrix is attached.

(3) New versions of MultiGen were received and installed. Unfortunately these versions lacked the DTED and DFAD input options, and so we continue to use the old versions until they send us the fully capable new code.

(4) The 9 track tape drive arrived and was installed, so we can now read anyone's DMA DTED and DFAD tapes without hindrance and install their information into databases, using MultiGen.

(5) Curt Lisle has been hired as a new fulltime IST employee and will assume command of this project when he returns from his honeymoon on 17 September.

PROBLEMS

S-1000 tools seem to be quite difficult for Larry Brown to install; he still doesn't have a working system. We are looking for ways to employ some E&S people and time so as to have some on-site assistance, and perhaps to build a good-sized piece of terrain from Ft. Rucker (see Moshell, Smart & Goldiez' trip report from Rucker this month for details).

Brief summary of Tolley's Stereo Extraction Algorithm

Algorithm based on the paper "Detection of Binocular Disparities" by K. Prazdny.

The algorithm for the stereo program compares two edge maps and forms a disparity map of matching points, shading pixels according to their disparity. The shade of gray is scaled according to the range of the disparity checked. Thus, if a disparity of +/- 6 is checked, the resulting picture would (potentially) contain thirteen shades of gray. Pixels shifted to the right are light gray, to the left dark gray, and pixels that match exactly are a middle shade of gray. For example, evaluating a Sobel edge map of the Pentagon picture at disparity 6 produces gray scale values of 18 for -6 disparity, 23 at +6, and 126 for a disparity of zero.

The program builds the disparity map by scanning the left image for edge points, then searching the right image for possible matches. It marks all possible disparities within the search range for each point in the array, and then evaluates these multiple choices to find the most probable match. A Gaussian distribution function weighs support values for each possible disparity, taking in account evidence from neighboring potential matches of similar disparity. After each disparity has been decided, a gray scale image is produced from the disparity map, shading the points with a value proportional to its disparity.

Building Extraction from Shadows - Dr. Kevin Bowyer /
Summary of Status, 1 August 1990

The essence of the project task is to evaluate the state of the art in automated methods for using shadows in aerial images to extract the height of buildings, and possibly other cultural features. (** Be sure to let me know if I have anything wrong at this level!) Accordingly the first two subtasks are (1) to gain an intellectual understanding of the state of the art by conducting a thorough literature review and summarizing the results in a review paper, and (2) to gain a more intuitive feel for the state of the art by actually implementing some of the methods discussed in the literature and independently evaluating their performance in our laboratory. The completion of these two subtasks will bring us to the point where we can reasonably specify the parameters of some capability in this area to be delivered to IST.

The literature review is approximately 90% complete. I have made already made corrections and suggested additions on a draft which covers the complete breadth of the project. I expect to review the the resulting draft within the next week and send a copy to IST for review in approximately two weeks. The review will cover the use of shadows as an image cue generally, as well as the specific task of recovering building height.

In preparation for evaluating some of the methods described in the literature, we have been contacting the authors of what we feel are the more important papers and asking them for copies of the images used to illustrate the methods in their papers.

We have obtained the images used in the paper by Nevatia (Heurtas and Nevatia, "Detection of Buildings in Aerial Images Using Shape and Shadows," 8-th International Joint Conference on Artificial Intelligence, 1983. Longer version also in CVGIP.)

We contacted Professor Pavlidis, but he was unable to supply us with the images used in his paper due to his student having graduated and his not being able to find the images (Liow and Pavlidis, "Use of Shadows for Extracting Buildings in Aerial Images," CVGIP 49, 242-277, 1990). This paper, anyway, did not directly address the question of estimating height of buildings.

We have also contacted David McKeown at Carnegie-Mellon University. (Irvin and McKeown, Methods for Exploiting the Relationship Between Buildings and Their Shadows in Aerial Imagery. Systems, Man, and Cybernetics 19, 1564-1575, 1989). He has been quite helpful in supplying us with reprints and technical reports describing his work. We have not yet received the images he has used, but he has promised to send the images, along with an independent measurement of the ground truth and an accompanying technical report, as soon as the whole package is complete.

Brief summary of Tolley's Stereo Extraction Algorithm

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Building Extraction from Shadows - Dr. Kevin Bowyer, [illegible]
Summary of Status, 1 August 1990

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Use of Shadows In Image Understanding
(08/28/1990 Draft)

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1 INTRODUCTION

Image interpretation is an essential step in several practical applications. In the area of modeling and simulation, 2-dimensional images often comprise the only source of information about a real world location for which a model is needed. The science of aerial photography has advanced greatly in the past few years and much of the equipment used in taking the actual photographs has become highly automated. However, the art of aerial photograph interpretation is still highly manual and primitive in comparison. Finding a way of automatically extracting the information available in 2-dimensional images can save an enormous amount of time and effort. The problem of automating the process of aerial photograph interpretation, though difficult, is not impossible to solve, Indeed, numerous researchers have already explored many different aspects of the problem [1, 2, 3, 4, 5]. Many of the basic image processing and interpretation techniques used in Computer Vision can be applied to aerial photographs, especially photographs of urban and suburban areas. Shadows play an important role in the process of interpreting 2-dimensional images. They have been used to serve several purposes that range from detecting the existence of 3-dimensional objects to estimating fairly accurate qualitative and quantitative features of objects in an image [1, 2, 3, 4].

The difficulty of interpreting 2-dimensional images of 3-dimensional objects lies mostly in losing the third dimension information. Shadows can be viewed to be the projection of this third dimension onto the plane of the 2-dimensional view and can be used to extract object features that are not explicitly available in their images. For shadows to be of value in calculating some of the features they reflect, information must be available about the source of illumination causing these shadows. In aerial images obtained on sunny days, the source of illumination causing shadows, the sun, is very well understood. By knowing the date and time of an aerial photograph, the location of the sun with respect to Earth can be accurately calculated. In this report, we present a discussion of previous work which concentrated on how shadows can provide information in an aerial image. We also explore work that used shadows to calculate features of buildings that cannot be directly measured in an aerial image, such as the height of a building.

2 THEORETICAL STUDIES

As general background, this section provides a review of previous theoretical work dealing with the relationship between objects and their shadows in images. We refer to the work reviewed in this section as "theoretical" because no real images are analyzed. The input to the algorithms

described here is assumed to be either a complete extracted line drawing, or a labeled line drawing that represents qualitative understanding of the scene in terms of the basic shape and position of objects.

In chapter two of the book titled " The Psychology of Computer Vision" [6] , David Waltz provides a discussion of extracting shadows and reconstructing three dimensional models from their 2-dimensional line drawings. In this study, an almost complete catalog of labels for the possible types of lines and vertices that can exist in a line drawing is provided. A set of working programs that attempt to assign a unique label to each line and vertex in a line drawing is also explored. For this particular set of programs, the labeling of the various lines and vertices is based mainly on geometric constraints. Limiting the number of labels that a particular vertex can have leads to imposing constraints on adjacent vertices. By increasing the constraints we place on the type of label that a vertex can have, we increase the possibility of producing a unique label for this vertex. Sahadows in this case present an important source of additional constraints that can be imposed on lines in the image. Without shadows, the identification of parts of the objects relative to their background becomes impossible.

Another researcher who explored the theme of geometric constraints between objects and their shadows is Shafer in his book "Shadows and Silhouettes in Computer Vision" [7]. In this book, the relationship between illumination source positions, objects and the shadows they cast is explored. Shafer started with solving what he called the "Basic Shadow Problem" and went on to provide solutions for progressively more complex scenes. He studied scenes of multiple curved objects and illumination sources. The simplest case, or the "Basic Shadow Problem", occurs when a single polygon casts its shadow on the background due to a single source of illumination. The solution to this problem is the base on which most analysis of the more complicated situations in the book was built. Although this particular work did not deal with real images, it provided several equations and geometric relations that can be valuable when applied to shadow information extracted from real images.

Recently, Singh and Ramakrishna [8] expanded the work done by Shafer and combined shadows and texture to find the shape of three dimensional objects from their two dimensional line drawings. They used the solution to the "Basic Shadow Problem" proposed by Shafer to find the shape and orientation of the various surfaces of a polyhedra based on shadow geometry. They also introduced a method for finding the shape of curved objects by calculating the gradients of points on the surfaces of these objects. Their calculations were based on shadow geometry constraints as well as texture.

3 SHADOW ANALYSIS IN REAL IMAGES

Shadow detection should not be viewed as an independent step which precedes object identification in the process of image interpretation. In fact, potential object structure areas in an aerial photograph are important to verify the existence of shadows in potential shadow areas and vice versa. Shadow extraction is a complicated process which is affected by many variables. To reduce the complexity of the process, researchers have imposed certain restrictions on the types of structures, and the intensity of the shadow areas relative to other components in an aerial photograph. Huertas and Nevatia [1, 2] for example, assumed that structures to be detected in

an aerial photograph are either rectangular or are composed of rectangular components. This assumption allowed them to find shadows by detecting pairs of perpendicular line segments obtained by some low level edge detection algorithm. Once such corners have been detected, further analysis is performed based on the direction of the sun illumination and the relational positions of pairs of detected corners. The boundaries of the rectangular areas in the image are then found by finding the groups of corners that could be connected to form a completed area boundary. In this work shadow areas are not segmented out in the actual image, but rather, shadow information is stored as a part of each corner description. Using the shadow information for each corner, they decide which corners are likely to belong to a structure boundary and which are likely to belong to a shadow boundary.

Irvin and McKeown [3] introduced a more comprehensive approach for using shadows in aerial photographs. They implemented separate algorithms for each of the various stages of the aerial image interpretation process. The reason for dividing the process into modules is to make it possible to combine more than one method for each stage of the interpretation process. For the stage of shadow extraction, they use an algorithm that finds shadow areas using simple thresholding and region growing techniques. An average shadow intensity value is calculated based on the values of the pixels adjacent to all the potential structure areas in the image. Only the pixels that are on the opposite side of the illumination source are considered since this is the side where shadows have to be if they exist. The calculated threshold value is then used in a region growing process to extract the shadow areas in the image. So far, this method does not impose any restrictions on the shape of structures nor their shadows in the image. Once shadow areas have been extracted, the structure side segments of the shadow boundaries are determined using knowledge of the direction of illumination. These segments are then extended into parallelograms which approximate the shapes of the structures in the image. This step restricts the structures that can be detected in an aerial image to parallelogram shaped structures. Irvin and McKeown also use shadows to group fragments that belong to the same structure in an image but are separated because of segmentation errors. The idea is that there is usually more consistency in color intensity within a shadow area that belongs to a certain building than there is in the building area itself. This reduces the chance for producing false area boundaries within the shadow area during segmentation. Based on this assumption, all the separate segments that are adjacent to the illuminated side of a shadow area can be grouped into one large segment that represents the building which cast the shadow.

Sometimes shadow areas can be used as a source of information without being explicitly extracted in an image. Some researchers found it useful to use shadow information at the level of segmentation and edge detection to produce more reliable structure boundaries in the image. Liow and Pavlidis [4] introduced two methods that used shadow/building edges as an initial source of reliable information for performing edge detection and region growing. The results of these methods are far better than any simple segmentation scheme because they take advantage of the sharp intensity of edges caused by the high contrast between structure areas and adjacent shadows. In their region growing algorithm, they use the pixels adjacent to a sharp edge which separates a structure area from its shadow area. These pixels are used as a representative sample from which they calculate the average intensity and the standard deviation among all pixels that belong to this structure area.

Thompson, Checky and Kaemmerer [9] used "shadow-stereo" to extract object boundaries

in 2 dimensional images. In their analysis of a scene, they use two sets of images. Each set is taken from a different camera position and within each set, images are captured under different sources of illumination. Edges that are raised from the ground such as those which represent object boundaries are distinguished from edges that are on the ground using the stereo images. Images taken under various sources of illumination are used to identify true boundary edges which would remain in the same position regardless of the direction of illumination. Other edges that shift in position depending on the direction of illumination are considered to be shadow boundaries. Although this work did not use aerial photographs as a source of input images, it can certainly be applied to aerial images. Of course, we cannot change the direction of the source of illumination (the sun), but we can take several stereo images at different times or even on different dates when the scene location changes its position with respect to the sun.

As we mentioned earlier, shadow analysis cannot be used as an independent source of information in the interpretation of aerial photographs. The use of shadows should be an integrated part of a full aerial image interpretation system. Nagao, Matsuyama and Ikeda introduced such system in [10]. In this system, all the various regions in the image are extracted and numbered. For each region found, they calculate all of the properties associated with that region, such as average intensity, location, shape, etc. Once these properties have been calculated, they are stored along with the region number in a table which they call "the basic property table". These calculated properties are used to identify the various elements in the actual real world location that each of the extracted regions in the image represent. In this system, shadows play their traditional role of aiding in identifying raised structures in an aerial image. To extract the shadow regions, they calculate some threshold value of brightnessbased on the average intensity among all pixels in the image. All regions in the image which have brightness lower than the calculated threshold are considered to be shadow regions. Once shadow regions have been identified, the regions which are adjacent to them in the direction of the sun and which have common boarders with them are considered to be regions that correspond to raised structures in the image.

Most methods which have been implemented so far are dependent on various assumptions and restrictions that limit their performance under various conditions. Due to the differences in contrast, illumination and quality of various aerial images many systems may consider some dark non-shadow areas in some images to be shadow areas. This problem may cause a false detection of objects or structures.

4 DETERMINING THE HEIGHT OF A STRUCTURE

Scientists have used shadows to accurately determine the height of buildings in aerial images [1, 2, 3, 11, 12]. Figure 1 shows the basic idea of how the height of a building (BH) can be calculated if the angle of the sun elevation with respect to Earth (x) and the length of the shadow (SL) are known. The following equation describes the important relation:

$$BH = SH \times \tan x \qquad (1)$$

The length of the shadow can be measured directly from the image. In general, finding the angle of the sun elevation requires a somewhat more complicated process. $x$can be found using one of the following methods:

1. If the height of an object in the image is already known, then by measuring the height of the shadow which this object casts on the background, we can use equation 1 to calculate the angle x. Once the value of x is known, it can be used to calculate other unknown object heights. The problem with this method is that it requires some prior knowledge about the image which is not always available. Also the chance for error in the final result of the calculated height is rather large since it depends on measuring two shadow height values from the image rather than one.

2. This second method allows the calculation of the sun elevation angle; x to be performed independently from the image. If the time, date and location of the photograph are known then x can be calculated, using astronomical tables, from the following relation:

$$\sin x = \cos a \times \cos b \times \cos c \pm \sin a \times \sin b \tag{2}$$

   where: a is the latitude of the photograph location, b is the latitude of the sun relative to Earth when the photograph was taken, and c is the difference in longitude between the sun and the photograph location.

   The sign in the equation is a " + " if both sun latitude and the photograph location are on the same side of the Equator, and it is a " − " if they are on opposite sides of the Equator. See figure 2. This is because the sun is located to the south of the Equator between September 23 and March 21, and it is located to the north of the Equator between March 21 and September 23.

These two methods give accurate results only if the following conditions hold:

1. The heights of the objects for which shadow heights are measured should be vertical with respect the image plane.

2. The entire surface of where the shadows are cast is in the plane of the image.

Figure 3 illustrates the problems that arise when one of these two conditions is not met.

5 UNSOLVED PROBLEMS

In any single image of a real world location, shadows represent the major source of information about the height of raised structures in that image. Using shadows to calculate building heights can produce accurate results. Many scientists have manually calculated heights of objects in aerial photographs using shadows and some have actually succeeded in automating the process. Most work which has been done in the area so far remains highly restrictive which makes it less useful in practical applications. Devising and implementing an algorithm that extracts shadow areas and identifies the properties of raised structures of arbitrary height and shape in an aerial photograph can be included as a part of a complete system of aerial photograph interpretation.

References

[1] A. Huertas and R. Nevatia. "Detection of buildings in aerial images using shape and shadows". In *The 8th International Joint Conference on Artificial Intelligence*, pages 1099–1951, 1983.

[2] A. Huertas and R. Nevatia. "Detecting buildings in aerial images". In *Computer Vision, Graphics, and Image Processing*, volume 41, pages 131–152, 1988.

[3] R. Bruce Irvin and Jr. David M. McKeown. "Methods for exploiting the relationship between buildings and their shadows in aerial imagery". In *IEEE Transactions on Systems, Man, and Cybernetics*, volume 19, pages 1564–1575, 1989.

[4] Yuh-Tay Liow and Theo Pavlidis. "Use of shadows for extracting buildings in aerial images". In *Computer Vision, Graphics, and Image Processing*, volume 49, pages 242–277, 1990.

[5] Jr. David M. McKeown and Jerry L. Denlinger. "Cooperative methods for road tracking in aerial imagery". In *IEEE Computer Vision and Pattern Recognition Conference*, pages 662–672, 1983.

[6] D. Waltz. Understanding line drawings of scenes with shadows. In *The Psychology of Computer Vision*, pages 19–91. McGraw-Hill, 1975.

[7] A. Shafer. *Shadows and Silhouettes in Computer Vision*. Kluwer Academic Publishers, Boston, 1985.

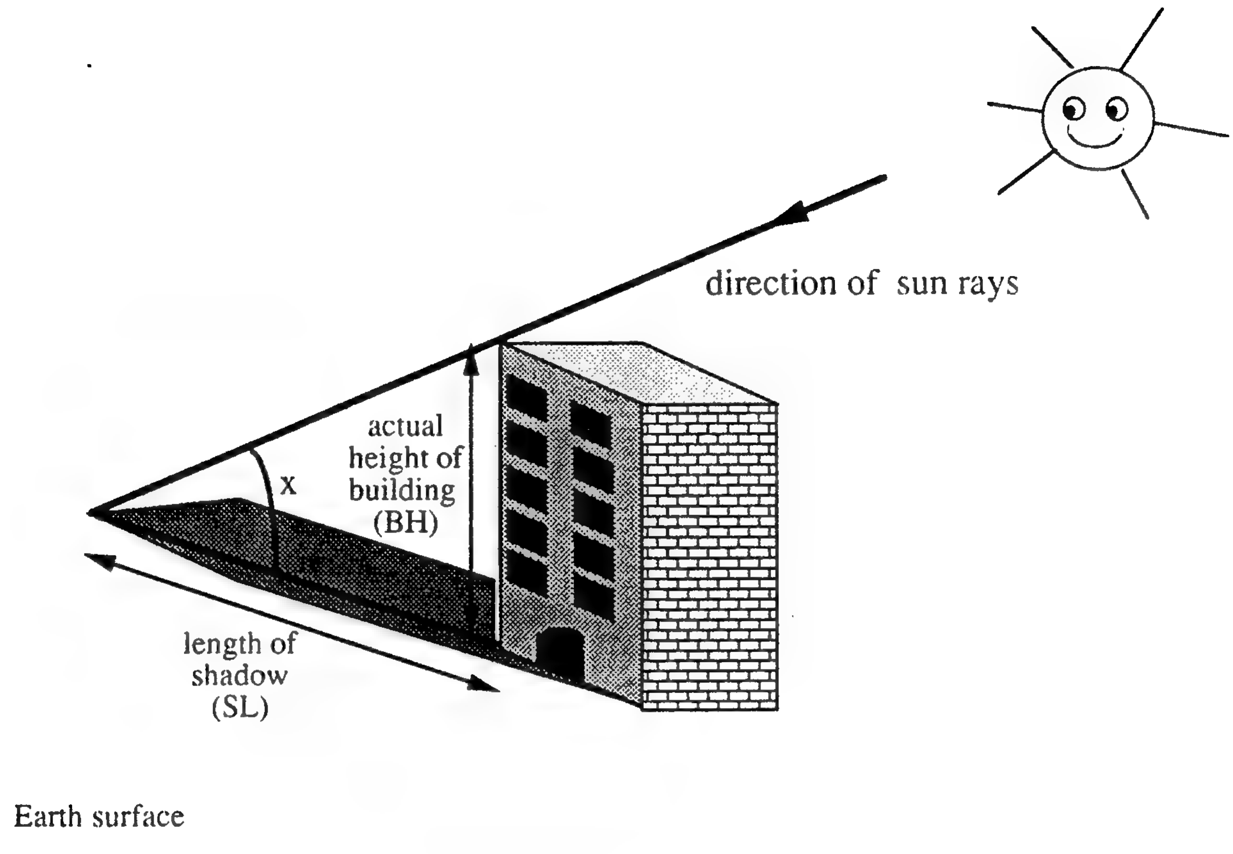
[8] R.K. Singh and R.S. Ramakrishna. "Shadows and texture in computer vision". In *Pattern Recognition Letters*, volume 11, pages 133–141, 1990.

[9] William B. Thompson, Michael T Checky, and William F Kaemmerer. "Shadow stereo - locating object boundaries using shadows". In *Sixth National Conference on Artificial Intelligence*, pages 761–766, 1987.

[10] M. Nagao, T. Matsuyam, and I. Ikeda. "Region extraction and shape analysis in aerial photographs". In *Computer Graphics and Image Processing*, volume 10, pages 195–223, 1979.

[11] T. E. Avery. *Interpretation of Aerial Photographs*. Burgess Publishing Company, Minneapolis, MN, 1977.

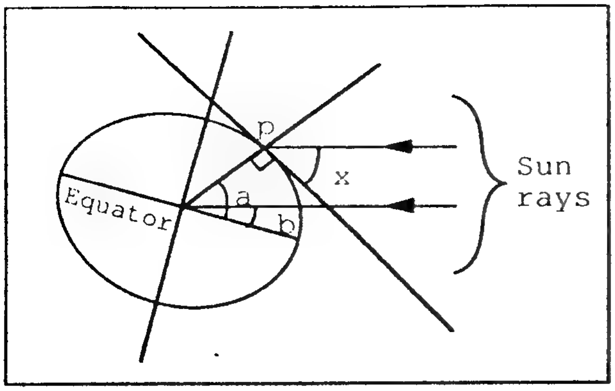
[12] John A. Howard. *Aerial Photo-Ecology*. American Elsevier Publishing Company, Inc., New York, NY, 1970.



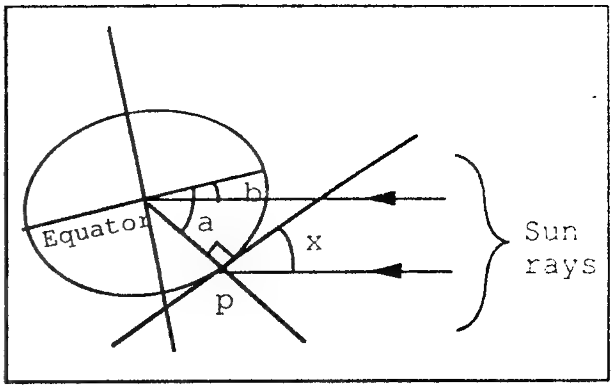
If the angle of the sun elevation "x" is known then the actual height of a building can be found using the length of its shadow from the equation:

$$BH = SL \tan(x).$$

Figure 1 - A structure height can be determined using shadow length.

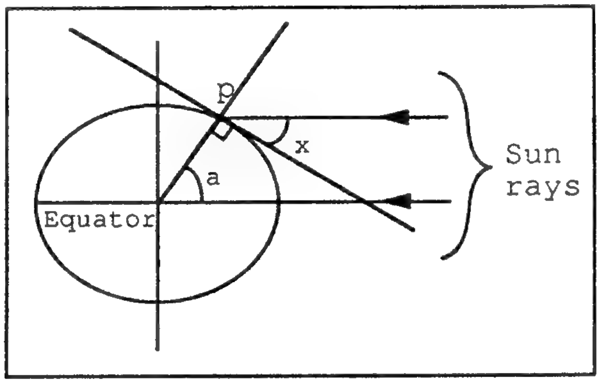


The sun has some latitute b above the equator (between March 21 and September 23) and point p is north of the equator.



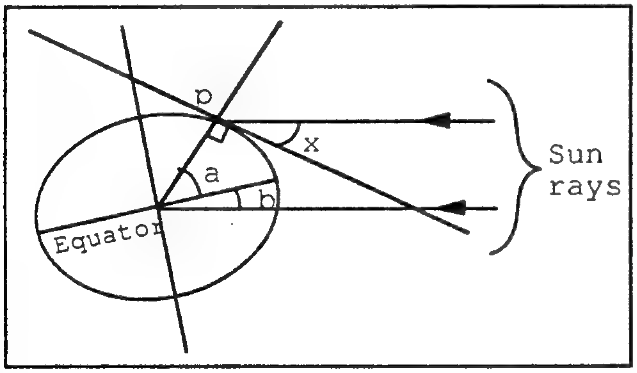
The sun has some latitute b below the equator (between September 23 and March 21) and point p is south of the equator.

$$\sin(x) = \cos(a-b) = \cos(a)\cos(b) + \sin(a)\sin(b)$$

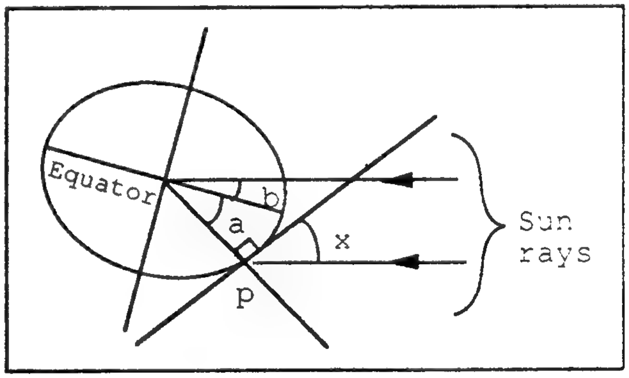


The sun has 0 latitute (i.e. the sun rays are perpendicular to the equator) on March 21 and on September 23.

$$\sin(x) = \cos(a)$$



The sun has some latitute b below the equator (between September 23 and March 21) and point p is north of the equator.



The sun has some latitute b above the equator (between March 21 and September 23) and point p is south of the equator.

$$\sin(x) = \cos(a+b) = \cos(a)\cos(b) - \sin(a)\sin(b)$$

Figure 2 - Calculating the angle of the sun's elevation "x" at point "p" which has a latitude angle "a" depends on the time of year.

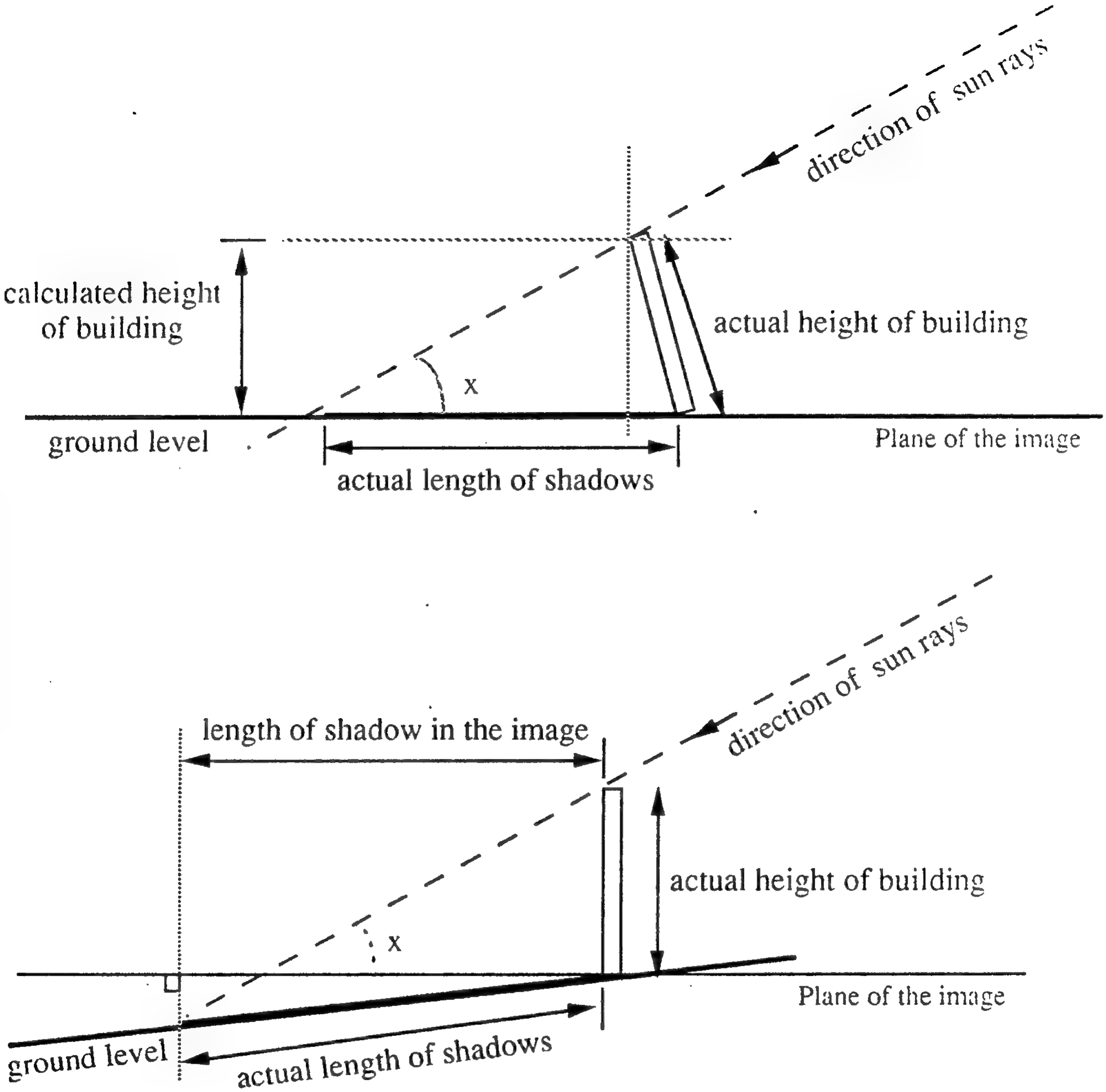


Figure 3 - If the shadow is not cast on the plane of the image or the building height is not perpendicular to the plane of the image then the calculated building height will be different from its actual height.

Annotated Bibliography
Use of Shadows In Image Understanding
(08/28/1990 Draft)

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The purpose of this annotated bibliography is to define the body of the literature which will lead to an understanding of the current state of the art in the area of using shadows to extract building models from aerial images. After an initial review of the literature, it appears that the most useful references are: Irvin and McKeown, Huertas and Nevatia, Liow and Pavlidis, and Fua and Hanson. It is clear that the current state of the art does not allow a reliable totally automated "image in - building model out" processing sequence. However, it does appear that a substantial degree of automation is possible. In the following list, you will find an overview of the books and papers that we have reviewed so far:

1. T. E. Avery. Interpretation of Aerial Photographs, Minneapolis MN:Burgess Publishing Company, 1977.
   Chapter 4 of this text provides detailed explanation of the method of using shadows to determine the height of an object in an aerial image. It also provides the equation controling the angle of the sun's elevation relative to Earth and explains how this angle can be used in the height determination process.

2. John A. Howard Aerial Photo-Ecology, American Elsevier Publishing Company, Inc., 1970.
   Chapter 15 of this text contains a good discussion of the determination of "apparent height" of an object in an aerial image from both shadow and stereo. The discussion is oriented more towards manual extraction of data from images and measurment of natural features (tree stands), however, it prvides the basic ideas in a clear fashion that they can be applied to man-made structures. This cahpter is also useful in that it provides detailed explanations of possible sources of error in applying the suggested techniques.

3. A. Huertas and R. Nevatia. Detection of Buildings in Aerial Images Using Shape and Shadows, The 8th International Joint Conference on Artificial Intelligence, pp 1099-1951, 1983.
   This paper describes an edge based technique which exploits clues provided by shadows of buildings in aerial images. Increasingly complex features are slowly constructed by using consistently interpreted intensity boundary segments. Feature interpretations are determined based on constraints imposed on the interpretations of observed intensity boundary fragments and groups of fragments by the imaging process.

4. A. Huertas and R. Nevatia. Detecting Buildings in Aerial Images. Computer Vision, Graphics, and Image Processing 41, 131-152 (1988).
   This paper is an expanded version of the earlier Huertas and Nivatia paper and it describe

a technique for extraction of buildings in aerial images. This technique uses shadows cast by these buildings to confirm their presence and estimate their height. The basic assumption introduced is that buildings that can be modeled as parallelpipeds. Shadows are used in labeling detected corners and confirming the existence of a 3-dimensional structure when a closed 2-D boundary is found. The proposed method consists of four basic steps:
(1) detection of lines and corners using some standard technique.
(2) labeling of corners as object or shadow corners.
(3) tracing object boundaries.
(4) verification of building hypotheses.
Results are shown for a pair of images of Los Angeles International Airport.

5. R. Bruce Irvin and David M. McKeown, Jr. Methods for Exploiting the Relationship Between Buildings and Their Shadows in Aerial Imagery. IEEE Transactions on Systems, Man, and Cybernetics, vol. 19 no. 6, pp 1564-1575, (1989).
This is a recent paper from one of the leading research groups in the area. In this paper the relationship between man-made structures and their shadows is used in devising computational techniques for extracting buildings from aerial images. Three programs are described, each of which exploits the presence of shadows in the image in different ways. "Shade" is the name of the program which does shadow detection . Shade identifies regions of the image which are likely to represent shadows of buildings. "Grouper" is another program that uses hypothesized shadow regions to group building regions which may represent fragmented portions of one building. "Shave" is a program that uses the presence of shadow regions in the image to verify that buildings actually exist in hypothesized building regions. Example results are given for two images from the Washington D.C. area. This work is important in that shadow analysis is used as one of multiple complementary techniques.

6. John R. Kender and Earl M. Smith. Shape From darkness: Deriving Surface Information from Dynamic Shadows, National Conference on Artificial Intelligence, 664-667, 1986.
This paper presents a method for extracting surface shape information based of object self-shadowing under moving light sources. One-dimensional dynamic shadows are analyized in the continuous case, and their behavior is categorized into three exhaustive shadow classes.

7. Yuh-Tay Liow and Theo Pavlidis. Use of Shadows for Extracting Buildings in Aerial Images, Computer Vision, Graphics, and Image Processing 49, 242-277 (1990)
This paper describes two approaches to the use of shadows in detecting buildings in aerial images. The first approach begins with a split-and-merge region growing segmentation stage. Somewhat oversimplified, the first approach does edge detection and then region growing, whereas the second does region growing first and then edge detection. The general philosophy of the work is to have multiple segmentation stages whose results can be combined to achieve more robust scene analysis. The emphasis is more on the low-level image segmentation techniques than on the recovery of building height. Results are illustrated using the same pair of images used by Huertas and Nevatia, as well as three

other images. It is claimed that the methods described here are applicable to buildings with textured roofs, and that building shapes are not restricted to being rectangular.

8. David M. McKeown, Jr. The Role of Artificial Intelligence in the Integration of Remotely Sensed Data with Geographic Information Systems. IEEE Transactions on Geoscience and Remote Sensing, vol. GE-25 No. 3, 330-348, (1987)
This paper discusses the possible role of AI in the design of geographic information systems. It begins with a short discussion of issues involved in using AI techniques to produce more powerfull geographic information systems. The remainder of the paper then illustrates some of these issues in the context of the MAPS system and applications based on MAPS. MAPS is a "spacial database" system which includes high resolution aerial imagery, a digital terrain map data and landmark data.

9. David M. McKeown,Jr. and Jerry L. Denlinger. Cooperative Methods for Road Tracking in Aerial Imagery, IEEE Computer Vision and Pattern Recognition Conference, 662-672, June 1983.
This paper provides a description of a system for road tracking called ARF (A Road Follower) in aerial imagery. This system is a multi-level architecture for image analysis that allows for cooperation among low-level processes and aggregation of information by high-level analysis components. two low-level methods are implemented; road surface texture correlation, and road edge following. A high-level module is then used to generate the final symbolic description of the road in terms of its various attributes.

10. Shafer, A. (1985) Shadows and Silhouettes in Computer Vision. Kluwer, Boston.
This book provides an analysis of shadow geometry starting with the simplest kind of shadow problem which occurs when a single polygon casts its shadow on a flat surface due to a fixed source of light. The book then provides discussions involving more complicated objects such as curved objects and solids of revolution under various sources of illumination. For each class of objects the book provides detailed explanations of the formulas constraining the geometry of the shadows.

11. Singh, R.K. and Ramakrishna, R.S. Shadows and Texture in Computer Vision. Pattern Recognition Letters 11, 133-141, 1990.
This paper explores the idea of using shadows in constructing 3-dimensional scenes from their 2-dimensional images. It also introduces a method for using texture as an additional source of information in cases where information extracted from shadows in not adequate for constructing the 3-dimensional scene. The solution to the basic shadow problem described by Shafer in his book (where a single polygon and a single source of light are considered) is explained and used in obtaining the shadow geometry for polyhedra. Using the information provided by shadows and texture combined as a method for constructing 3-dimensional scenes for objects with curved surfaces is also given. No results of real image examples are given in this paper.

12. William B. Thompson, Michael T Checky and William F Kaemmerer. Shadow Stereo - Locating Object Boundaries Using Shadows, Sixth National Conference on Artificial Intelligence, 761-766, July 1987.

This paper describes a method for reliably detecting shadow edges corresponding to object edges. This method is able to distinguish between detected edges due to shadow and those due to surface markings. A simple stereo technique which does not require a solution to the general correspondence problem is described. In this technique, a multi-light source method or a multi-camera method can be implemented.

13. D. Waltz. Understanding Line Drawings of Scenes with Shadows, in The Psychology of Computer Vision, P.H. Winston, ed., New York: McGraw-Hill, 1975.
This paper describes some of the earlier work which deals with the relationship between idealized objects and their shadows. Elaborate description for junction and line labeling techniques are given. Also several programs that give 3-dimensional information from 2-dimesional images of objects with planner surfaces are described in details. Although this paper describes the relationship between shadow geometry and the objects causing these shadows in great details, this work applies mostly to idealized objects rather than actual images.

14. Pascal Fua and Andrew J. Hanson. Using Generic Geometric Models for Intelligent Shape Extraction, DARPA Image Understanding Workshop 1987, 227-233.
This paper provides a model-based implemention for identifying objects in an aerial photograph. The models used to identify the objects are not simply regid templates that can be matched to objects in the image, but rather, they use deliniations that describe generic classes of objects. They use edges in the image to extract the various areas and then test which of these areas correspond to which of the generic models which they have designed. If any of the areas extracted does not correspond to any of the models then the system is able to predict the shape of the missing parts and complete the boundaries of such areas.

15. M. Nagao, T. Matsuyama, and I. Ikeda Region Extraction and Shape Analysis In Aerial Photographs, Computer Graphics and Image Processing, vol 10, no. 3, 195-223, July 1979.
This paper describes a complete system for interpreting aerial photographs. The system has several levels of processing. The highest level performs a basic segmentation of the whole image and produces boundaries for various areas within the image. Each of these boundaries is assumed to represent an element in the real world location. The next level in the process examins each of the areas found to determine its various properties, such as shape, size, brighness, location, etc. Based on this analysis of each area, the system may continue in one of several directions depending on the particular objective of running the algorithm and on the basic area types found in the image.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report, contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
27 September 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 AUGUST 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$44,987.04	$40,376.43	$23,814.51	$19,203.89	$8,885.50	$10,318.39
TRAVEL	$115.00	$115.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$5,691.36	$2,845.68	$2,845.68	$3,180.78	$1,590.39	$1,590.39
INDIRECT COSTS *	$34,298.67	$21,235.18	$13,063.49	$10,968.49	$5,133.19	$5,835.30
TOTAL EXPENDITURES	$85,092.07	$64,572.29	$39,723.68	$33,353.16	$15,609.08	$17,744.08

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 30 AUGUST						
SMART	123.00	61.00	62.00	28.00	14.00	14.00
KLASKY	654.00	606.00	48.00	0.00	0.00	0.00
MORIE	200.00	0.00	200.00	120.00	0.00	120.00
BOWYER	296.00	296.00	0.00	120.00	120.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	431.00	72.00	359.00	187.00	0.00	187.00
MOSHELL	132.00	78.00	54.00	104.00	52.00	52.00
LISLE	534.50	0.00	534.50	203.50	0.00	203.50
STARK	480.00	480.00	0.00	80.00	80.00	0.00
SAMKOWIAK	2.00	1.00	1.00	2.00	1.00	1.00
WATKINS	216.50	66.00	150.50	75.50	0.00	75.50
ROY	67.00	67.00	0.00	0.00	0.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	3249.00	1743.00	1506.00	920.00	267.00	653.00

Monthly Report September 1990
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. Work continues on the CAD-style package to be built by Maha Sallam and Kevin Boyer. This package will allow the "manual" shadow analysis of an image. It will output polyhedral descriptions of objects (buildings) in the image. This data will then be converted to run on the ESIG 500 located at ITS/VSL. This will allow an interactive flyby of the objects detected by the shadow analysis. Maha and Boyer will deliver the shadow analysis programs to Brian Blau on October 15. Work will then being translating their data to run on the ESIG 500.

2. Mubarik Shah and Derrik Tolley continue to implement stereo algorithms which extract the depth of objects which are in an image. One algorithm is based on edges in the image, and gives a sparse depth map. The other algorithm is based on correlation and will produce a dense depth map. Planned delivery of these programs to Brian Blau is the end of October.

3. Chuck Campbell is working on another CAD-style package in conjunction with Shah's and Tolley's stereo programs. This CAD-style program will let the user "manually" select features of an object and place them in a database. This database can then be used in an interactive flyby of the objects that were detected by the stereo algorithms.

4. Chuck Campbell is continuing his literature search on cartographic imagery.

5. A visit and presentation was made by Image Data Corporation on August 31. Their beta version software demonstrated building extraction algorithms using shadows, similar to those being investigated by Maha and Boyer. Their product has only had limited release and was only available on a few workstations. Possible help to this project: not much in the near future, but will keep in contact with them as their product line expands.

6. Attached is a detailed timeline for the remaining of the calendar year.

Problems

None at the present time.

Timeline for the Geospecific Database Project (Sept 1990)

September		October				November					December	
21	28	5	12	19	26	2	9	16	23	30	7	14
#1	#2			#3				#4	#5	#6	#7	

(all dates are Fridays)

#1 Work to be done: Final plan due for CAD package. Begin working on CAD package.
By who: Blau and Campbell.
By when: Friday, Sept 21. (may change if Shah and Boyer need more time on #2)

#2 Work to be done: Based on the work done since 8-29, commit to dates set in this timeline.
By who: Blau, Boyer, Shah
By when: Friday, Sept 28.

#3 Work to be done: Receive work done by Boyer and Shah. Work out any bugs with their programs. Get X11 working on the Sparc Station.
By who: Blau, Boyer, Shah, Nelson.
By when: Friday, Oct 19.

#4 Work to be done: Complete work of CAD package. The complete path from images to image generator should be working by this time. Work out any bugs in everyone's code. Make a package of software to distribute which includes all of our combined work. Visit from Boyer and Shah to see everything work.
By who: Blau and Campbell.
By when: Friday, Nov 16. (Visit could be on Nov 23 if not ready)

#5 Work to be done: Have ready a document which will include all of the bibs, papers and related work done so far. All documentation will be done at this time. - Program docs, - Related papers, - Cartographic literature search.
By who: Blau and Campbell.
By when: Friday, Nov 23.

#6 Work to be done: Make the final plans for the demonstration to the sponsors. Give a dry run of the demo to M. Moshell.
By who: Blau.
By when: Wednesday, November 28.

#7 Work to be done: Demonstration for the sponsor. All attend.
By who: Blau, Campbell, Moshell. (Shah and Boyer out of the country)
By when: Mon, Tue or Wed December 3-5.

Prepared by Brian Blau
9/17/90

Project Monthly Report - September 1990
Multiple IG Databases (MIDB) Project
Project Lead: Curtis Lisle

Accomplishments:

1. ***Installation of S-1000:*** The S-1000 version received from BBN has been installed at IST and is partially functional. Additional texture libraries and bug fixes are still needed. We have received BBN's consent to get the texture library from ETL. To further support IST's efforts on S-1000, a time and materials support contract with BBN is planned.

2. ***MultiGen to ESIG Interface:*** A test database containing the Research Pavilion and NTSC building at Research Park was modeled in MultiGen, converted by Chen Jinxiong's filter, and displayed on the ESIG. The filter does not handle generating all the priority information necessary for the ESIG, but produced visually-pleasing results for an early test case.

3. ***VISTA to ESIG Texture Formatter:*** Work has begun on a conversion program to allow new ESIG texture maps to be generated by the VISTA/TIPS paint package (which runs on IBM PCs). This will be a cheaper and faster solution than buying additional texture tools from Evans and Sutherland.

4. ***DTED and DFAD Data:*** DTED and DFAD data have been read into the MultiGen system using the nine track tape drive. The effort to import DTED into the S-1000 system has begun.

5. ***Database System Comparison Report:*** Jacki Morie completed a comparison report which supplies an overview of the BBN S-1000 system, the E&S ESID system, and Software Systems' MultiGen system.

6. ***Ft. Rucker Database:*** IST/VSL is considering the possibility of developing a Ft. Rucker database using S-1000 for ARI. Several ARI personnel from Ft. Rucker visited IST and described their current projects and the needs for their future work.

Project Monthly Report - September 1990
Multiple IG Databases (MIDB) Project
Project Lead: Curtis Lisle

Current Problems:

The S-1000 system must be completely operational before work can begin on the MultiGen to S-1000 interface. The S-1000 system is not intuitive and, at this point, we have poor documentation and a poor support level from BBN. Installing and using this tool will be harder than originally expected.

MIDB Project Timeline
Curtis Lisle
Sept. 24, 1990

The goal of the MIDB project is to construct a database development environment which simultaneously supports multiple Image Generator (IG) architectures. The databases created will only need to be developed once and will be processed by reformatting tools to allow them to run on different IGs.

Since a single database source will be processed by different formatters, the subject of database correlation will be addressed. In this context, correlation refers to the process which guarantees that the IG databases (produced by the MIDB formatters) are consistent and accurate with respect to each other (all the features are in the same place, etc.).

Timeline:

September		October				November					December	
21	28	5	12	19	26	2	9	16	23	30	7	14
		#4		#1	#2		#3		#5,#7		#6 (?)	

(all dates are Fridays)

Description of Timeline Tasks:

Task #1:
Train on S-1000: Curt Lisle and Jacki Morie will train in the use of the S-1000 system. By completion of this task, Lisle and Morie will be proficient in the S-1000 interface and able to construct simple visual databases. Documentation is still lacking for some of the S-1000 modeling tools (otherwise, this would be a two week process).
Deliverables: Two educated and happy S-1000 modelers
MIDB personnel: Brown, Lisle, Morie

Task #2:
Port S-1000 database to SIMNET: Several of the simple databases constructed during task #1 will be compiled, formatted, and run on the SIMNET tanks at IST.
Deliverables: Demo of database on SIMNET
MIDB personnel: Brown with Morie (observing)

Task #3:

Define S-1000 formats: Once simple databases are constructed with S-1000, these (along with the S-1000 documentation) will serve as models to study the S-1000 datafile formats. At the completion of this task, a specification (spec) will be written describing how to format, arrange, and store a database in S-1000 format.
Deliverables: S-1000 datafile spec
MIDB personnel: Morie, Lisle

Task #4:

VISTA to ESIG texture formatter: Develop a prototype interface to generate ESIG texture files from VISTA format pictures. This allows the creation of additional ESIG texture maps and defines the format in which ESIG texture will be created by later tools. A spec document will be produced which describes the ESIG file format and the formatter program.
Deliverables: Formatter program, ESIG texture spec
MIDB personnel: Buckley, Klasky

Task #5:

Multigen to ESIG interface: Develop a formatter which reads Multigen-format datafiles and produces ESIG-format datafiles. A spec document will describe the interface program. The formatter program will not support all the explicit polygon priority-ordering necessary for the ESIG.
Deliverables: Formatter program, formatter design spec
MIDB personnel: Jinxiong, Klasky (help with spec)

Task #6:

Design Multigen to S-1000 interface: Since the interface output format is defined by the spec from task #3, design work can begin on the interface. The interface will read Multigen-format datafiles and produce S-1000-format datafiles. Depending on the interface complexity, this step may also include prototype development. The completion date of this phase is only tentative, it will be firmed up when more detail is known about the S-1000 database formats.
Deliverables: Design document, interface prototypes (possible)
MIDB personnel: Lisle, Morie, Jinxiong

Task #7:

VISTA to S-1000 Texture formatter: Investigate the feasability of converting VISTA files into S-1000 texture files. If possible, a prototype formatter will be written and demonstrated.
Deliverables: if feasable, a formatter program and documentation
MIDB personnel: Buckley

Future MIDB Directions:

The ESIG formatter described in Task #5 does not sufficiently order the database polygons with respect to each other so the ESIG can correctly display them in all cases. An ordering algorithm, similar to BSP trees, must be developed to complete the MultiGen to ESIG path. This will be addressed after the completion of Task #5.

Once the above tasks are completed, we be able to create a database once using MultiGen, format it for two different IGs, and begin work on the database correlation issue. The MIDB project will:

1. Find what correlation work has already been done through a literature search and discussions with IG database vendors.

2. Develop metrics to measure the correlation between different databases and investigate the feasablity of automatic correlation tools.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report, contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
28 November 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 OCT 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$96,381.01	$52,913.17	$43,467.84	$17,313.98	$5,291.51	$12,022.47
TRAVEL	$1,594.96	$854.99	$739.97	$67.19	$33.61	$33.58
OTHER DIRECT COSTS	$5,796.66	$2,898.33	$2,898.33	$0.00	$0.00	$0.00
INDIRECT COSTS *	$50,067.74	$27,342.31	$22,725.43	$8,297.08	$2,518.53	$5,778.55
TOTAL EXPENDITURES	$153,840.37	$84,008.80	$69,831.57	$25,678.25	$7,843.65	$17,834.60

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 25 OCT						
SMART	167.00	83.00	84.00	16.00	8.00	8.00
KLASKY	814.00	606.00	208.00	0.00	0.00	0.00
MORIE	394.00	0.00	394.00	168.00	0.00	168.00
BOWYER	376.00	376.00	0.00	0.00	0.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	591.00	72.00	519.00	80.00	0.00	80.00
MOSHELL	240.00	138.00	102.00	32.00	16.00	16.00
ALTMAN	182.00	128.00	54.00	0.00	0.00	0.00
LISLE	185.00	0.00	185.00	160.00	0.00	160.00
BUCKLEY	609.00	0.00	609.00	74.50	0.00	74.50
STARK	720.00	720.00	0.00	120.00	120.00	0.00
SAMKOWIAK	10.00	5.00	5.00	8.00	4.00	4.00
JINXIONG	80.00	0.00	80.00	80.00	0.00	80.00
BLAU	160.00	160.00	0.00	160.00	160.00	0.00
MANGUM	103.50	0.00	103.50	85.25	0.00	85.25
WATKINS	216.50	66.00	150.50	0.00	0.00	0.00
CAMPBELL	158.00	158.00	0.00	80.00	80.00	0.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	5186.00	2595.00	2591.00	1063.75	388.00	675.75

Project Monthly Report - November 1990
Multiple IG Databases (MIDB) Project
Project Lead: Curtis Lisle

Accomplishments:

1. ***S-1000:*** Jacki Morie and Curtis Lisle are continuing to train on the S-1000 system. Arrangements have been made for Morie and Lisle to train at ETL in December by involving them in ETL's S-1000 activities. We received information from BBN on how to build articulated models in S-1000 (see the PRC effort description below).

2. ***MultiGen to ESIG Interface:*** Development work on the interface is continuing. In particular, color attributes for database polygons are now transferred to the ESIG correctly. The interface must generate additional priority information since the ESIG needs a priority-resolved database. The demonstrations IST has produced so far have not included correct inter-object priority. Software Systems agreed to help IST solve the priority resolution issue for MultiGen databases.

3. ***Project 2851:*** Discussions were held with Software Systems about the progress of P2851. IST/VSL and Software Systems agreed to cooperate on the development of a 2851 to MultiGen flight formatting process. IST sent a request to P2851 restating our interest in receiving a copy of the next GTDB distribution.

4. ***PRC NLOS Icon:*** Negotiations between PRC and IST are continuing over the schedule and what deliverables IST will provide to PRC. The S-1000 training which Morie and Lisle will receive at ETL in December should enable IST to develop the required compiled icon. The icon needed by PRC is a HMMWV vehicle with an articulated rocket launcher.

5. **ITSC Demo:** Several members of the MIDB team were involved in the ITSC demonstration given by IST at the UCF/Research Park conference booth. We demonstrated moving models (tanks) interacting and dynamically cratering a piece of SIMNET terrain extracted from one of IST's SIMNET systems.

6. **Database Correlation:** IST is coordinating with Dr. Kate Kinsley on a literature search of DOD simulation papers. Several

more articles were reviewed and summarized toward a goal of producing a paper summarizing the best DOD-sponsored work in the area of database representation and correlation.

Current Problems:

We submitted a request to BBN on 11-November to establish a consulting contract with IST. This contract would enable us to get technical support from BBN on S-1000 and the SIMNET CIG as problems are encountered during the MIDB project at IST. We have received no answer from BBN so far. This continues to slow our progress.

Monthly Report November 1990
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

Xwindows is now up and running on two Sparc workstations and one Silicon Graphics workstation. Xwindows was necessary for the operation of the height from shadow program from Dr. Bowyer and Maha Sallam. With Xwindows, it is possible to run a program on one machine while working on another, which allows greater flexibility in the lab.

Bowyer and Sallam will be at IST on Nov. 28 to discuss the status of the project. While they are here, we hope to resolve the problem we are having with running their program, described below in the problems section.

Chuck Campbell has modified Bowyer and Sallam's algorithm to produce output compatible with Lisle's ANIM program for display on the Silicon Graphics workstation. Currently, all buildings have a fixed height, due to the problems we are experiencing with the program, but only a slight modification should be required to use the calculated building height once the problem is resolved.

During I/ITSC, we discovered that GE is doing work in the same area we are. They demonstrated construction of a 3-D database from a pair of images, although they claimed they can use only one image. They also demonstrated extraction of building features. In addition to this, they are also doing some work calculating building height from shadows, although they had no demonstrations of this. Their work was very impressive, and we believe it would be a good idea to talk with them further.

Problems

We have not been able to produce correct output from Bowyer and Sallam's program. We get accurate values for the building and shadow traces, but the calculation of the shadow length and building height produces obviously incorrect answers. After correspondence with Bowyer and Sallam, we believe the problem to lie in the operating environment and not with the user or the program.

A requirement specification for the current UPAS project which describes the concepts of the AAR aids and the requirements for UPAS task 2 has been received by IST from Dr. Meliza, ARI. With that specification, IST has a better understanding of the user's requirement and will be better able to accomplish the project goal that meets the user's needs.

PLANS

- Finish up the review and update of the UPAS in-line documentation performed by Perceptronics
- Have Perceptronics fix the known UPAS software bugs and update the UPAS user's guide as per Dr. Meliza's review comments
- Finalize the UPAS task 1 acceptance test plan and get ready for the acceptance test
- Run upgraded UPAS software on SIMNET 6.6 exercise data to see if they are compatible as per ARI's request
- Continue to work on the other UPAS tasks

UNIVERSITY OF CENTRAL FLORIDA
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12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

November 28, 1990

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the November 1990 time period are forwarded for your review and/or approval.

If you have any questions, please call me at 658-5014 or 658-5000.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report, contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
December 1990

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 NOV 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$113,423.90	$57,591.20	$55,832.70	$17,042.89	$4,678.03	$12,364.86
TRAVEL	$1,594.96	$854.99	$739.97	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$6,674.89	$3,389.19	$3,285.70	$878.23	$490.86	$387.37
INDIRECT COSTS	$58,715.76	$29,813.04	$28,902.72	$8,648.02	$2,470.73	$6,177.29
TOTAL EXPENDITURES	$180,409.51	$91,648.41	$88,761.09	$26,569.14	$7,639.61	$18,929.52

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 22 NOV						
SMART	197.00	99.00	98.00	30.00	16.00	14.00
KLASKY	974.00	606.00	368.00	160.00	0.00	160.00
MORIE	506.00	0.00	506.00	112.00	0.00	112.00
BOWYER	376.00	376.00	0.00	0.00	0.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	671.00	72.00	599.00	80.00	0.00	80.00
MOSHELL	252.00	138.00	114.00	12.00	0.00	12.00
ALTMAN	182.00	128.00	54.00	0.00	0.00	0.00
LISLE	345.00	0.00	345.00	160.00	0.00	160.00
BUCKLEY	647.75	0.00	647.75	38.75	0.00	38.75
STARK	840.00	840.00	0.00	120.0[illegible]	120.00	0.00
SAMKOWIAK	12.00	6.00	6.00	2.00	1.00	1.00
JINXIONG	80.00	0.00	80.00	0.00	0.00	0.00
BLAU	320.00	320.00	0.00	160.00	160.00	0.00
MANGUM	209.00	0.00	209.00	105.50	0.00	105.50
WATKINS	216.50	66.00	150.50	0.00	0.00	0.00
CAMPBELL	238.00	238.00	0.00	80.00	80.00	0.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	6246.25	2972.00	3274.25	1060.25	377.00	683.25

Monthly Report December 1990
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. On November 28, Kevin Boyer and Maha Sallam made a visit to IST/VSL. During there visit, Sallam was able to fix the problems that were in the height from shadow algorithms. Now that these problems were fixed, its output is now correct. This output is used as input to the display program running on the Silicon Graphics workstation. During this visit, there was some discussion of enhancements to their programs. This would probably be delivered during January.

2. Curt Lisle from IST/VSL is making contact at General Electric Simulator Division in Daytona Beach. We would like to see their image processing/database generation software that was demonstrated at the I/ITSC conference. This meeting will be scheduled for sometime in January and will be attended by Blau, Campbell, Moshell, Shah, Boyer and Sallam.

3. All of the programs that were scheduled for completion are now finished. There are four main programs which were developed :

#1 Shah	Scene depth from disparity map
#2 Campbell	CAD program to interactively build database from #1's output
#3 Boyer & Sallam	Building height from shadows
#4 Campbell	Interactive display of building height

Full documentation for these programs is currently being written. This documentation should be completed by the end of January. Also, Campbell will be preparing a distribution tape of the programs developed.

Problems

All of the programs developed run either on a Sun or Silicon Graphics workstations. The goal is to have all programs running on the Silicon Graphics. To do this, more Xwindows include files and libraries need to be acquired. This should be done by January and all programs should be working on that platform by then.

Project Monthly Report - December 1990
Multiple IG Databases (MIDB) Project
Project Lead: Curtis Lisle

Accomplishments:

1. ***S-1000:*** Curtis Lisle and Jacki Morie spent one and two weeks, respectively, at ETL in Ft. Belvoir, VA. They received training on BBN's S1000 database tools by working on ETL's database development project. IST is now familiar enough with S1000 to develop and view new databases on IST's two SIMNET CIGs.

2. ***SIMNET Real-Time Software:*** As IST develops terrain databases and moving models for the SIMNET CIGs, It will become more necessary to configure and use BBN's real-time software (RTS) protocol in order to accomplish our goals. We have received little support from BBN regarding their RTS environment. This has not impacted our progress yet, but it may cause delays in the future.

3. ***ITD data:*** IST has just begun an effort to develop ITD data importing tools. At this time, our goal is to import ITD data into the Flight format suitable for Software System's MultiGen. This will enable ITD data to be viewed on both E&S and BBN CIGs when IST's formatting programs are finished.

4. ***Project 2851:*** Jacki Morie contacted Tony DelSasso of P2851 and found they are planning a database distribution in Summer 1991. He said that an early release might be possible to IST. We are continuing to follow the progress of P2851.

5. ***PRC NLOS Icon:*** IST now has the technical expertise to develop the icon needed by PRC. This will serve as a good first test case for a multiple LOD, articulated model constructed here at IST. Work on the icon is expected to be completed by the end of January 1991.

6. **Database Correlation:** The literature search with Dr. Kinsley is continuing. Ron Klasky and Dr. Bruce MacDonald have written a proposal addressing future work directions for IST in this area.

7. **ESIG Host Development:** Robert Mangum is finishing up work on the ESIG-PC network link. This link allows remote control of the ESIG from any PC with an ethernet contoller. For speed

considerations the code is written in Assembly. This does not allow for the portability of the software and so it will be re-written in C.

8. Polygon Relaxation: A polygon relaxation software system is being developed. This will combine co-planar polygons into larger polygons, thus reducing the overall polygon count in a simulator database. Code is being developed by K Bryden, B Blau, and J Chen. A paper is also being prepared describing the algorithm and should be finished by the end of January 1991. These tools will allow relaxation of MultiGen format terrain files.

Current Problems:

We submitted a request to BBN on 11-November to establish a consulting contract with IST. Last month I reported that we had no response from BBN. This is still true. As we continue to use BBN's software and hardware, our needs from BBN will be small but increasing. We must forge some sort of working relationship with them in order to avoid a slow reverse-engineering process.

UNIVERSITY OF CENTRAL FLORIDA

INSTITUTE FOR SIMULATION AND TRAINING

12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

December 27, 1990

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the December 1990 time period are forwarded for your review and/or approval.

If you have any questions, please call me at 658-5014 or 658-5000.

Sincerely,

Ernie Smart
Program Manager

UNIVERSITY OF CENTRAL FLORIDA

INSTITUTE FOR SIMULATION AND TRAINING

12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

December 28, 1990

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Green:

The attached Trip Report to ETL (Engineer Topographic Lab) by Curtis Lisle was inadvertantly left off the December monthly progress report. Because the information is current and relevant, it was decided not to wait for next month's report .

If you have any questions, please call me at 658-5014 or 658-5000.

Sincerely,

Ernie Smart
Program Manager

cc: Dr. Ronald Hofer
Mr. Stan Goodman
Mr. Karl Driskell
Mr. Gene Wiehagen

Trip Report

Dates: December 10-14, 1990

Location: Army Engineer Topographic Lab (ETL)
Ft. Belvoir, VA

IST Personnel: Curtis Lisle

Persons Visited: George Lukes (ETL)
Doug Carl (ETL)
Jay Banchero (BBN)

Purpose:

The purpose of the trip was to gather as much information as possible about BBN's S1000 modeling environment. IST and ETL agreed that, by imbedding me in their database development project, I could learn the S1000 tools and they would benefit through increased progress on their project.

This document is divided into two sections. The first (brief) section covers the itinerary of the week I spent at ETL. The second section outlines many of the major pieces of information acquired through training, experience, or discussions with ETL employees.

Itinerary:

12/10/90 - arrived at Washington-National at 10:30
George Lukes said meet after lunch, arrived at 1:30
met with George, Jay, Doug for an introduction.

12/11/90 - trained on the S1000 Model tool in the morning;
Gathered DB source data; began modeling static objects.

12/12/90 - Modeled buildings and placed models on terrain with the assembly tool. Compiled a test database. We could not move the DB over to the CIG because of problems with the Masscomp host.

12/13/90 - Placed our buildings on the final database according to SPOT image coordinates and the road networks already in the database. Used the CIG to fly over the test database and see our models. Compiled the final database. Met with George Lukes to discuss ITD,

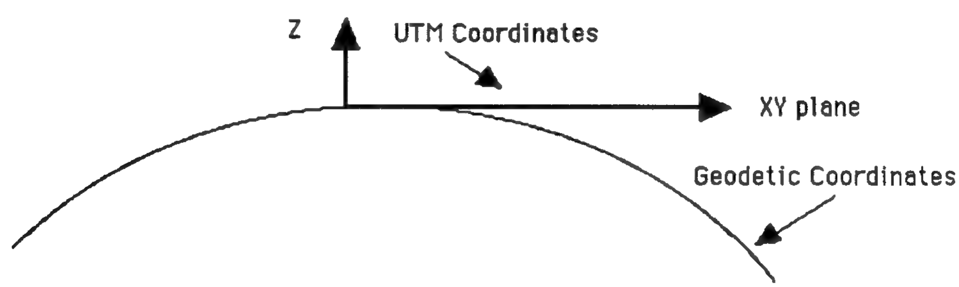
GIS systems, ETL and IST cooperation, etc.

12/14/90 - Flew over the final database on the CIG. Jay taught us the process for constructing multiple LOD and articulated models. Jay showed me the process for transferring and loading databases on the CIG.

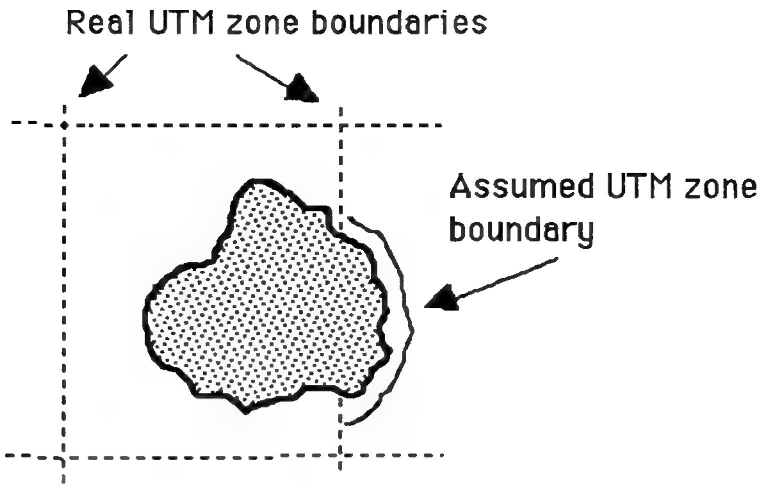
Concepts Learned at ETL:

Cartography:

1. Problems occur at the boundaries between UTM zones since the Earth bends away from the straight UTM coordinates.



If a database extends across a UTM boundary, the boundary is usually moved until the entire database is contained in one UTM area. The limit of this fudge is about 40 km. before the error gets too large. This is necessary because UTM coordinates are derived by converting from Geodetic coordinates. The position of the SouthWest corner of each zone is calculated then offsets are measured from imagery, maps, etc. to find the final positions. When a boundary is "extended" as shown below, this means features in the new zone are positioned as offsets with respect to the base location of the adjoining zone (which would only be accurate if the Earth was flat).



2. The Kuwait/Iraq area of the Middle East lies across UTM boundaries. UTM zones are every 8' x 6' (Doug Carl's guess).

3. Different data sources ("datum's") do not agree on their positioning, i.e. SPOT imagery may not have the same positioning as European 1:50k maps. This means the actual constructed database is up to the modeler and may be inaccurate.

4. Unclassified source data is usually not high enough detail to craft an accurate, good looking DB (database) for ground battle rehearsal. Different sources available:

> **<u>1:50000 maps</u>**- high resolution maps which shows some cultural features (buildings, docks, roads, etc)
>
> **<u>SPOT imagery</u>** - French satellite photos which are useful because they are marked with coordinates already (easy to correlate). Resolution is good enough to find coastlines, land features, large buildings, etc. Useful for direct digitizing of roads.

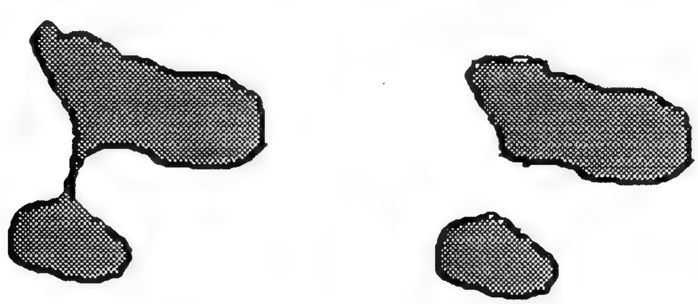
JOG map - (Joint Operations Graphic) This is a military map which is usually at 1:250k scale and is designed to coordinate multiple-service operations (Army, Navy, etc.).

TPC map - (Tactical Pilots Chart) 1:500k showing only pipelines, power wires, bodies of water, etc. This is often digitized from the JOG hardcopy, so it is not a good "second opinion" for JOG data.

Tourist info - Shows pictures of major buildings, locations of attractions, museums, etc. This was useful for the Desert Shield operation in Kuwait City since tourist maps and books were available.

Classified Sources - Imagery at higher resolution is available from classified sources. This format would be used if the highest possible detail was desired for mission rehearsal.

5. The time the image or map was made is often important. Water bodies change shapes, construction projects remove islands, etc. Example: flooded regions between Iraq and Iran were constructed during the Iran/Iraq war. *Finding up-to-date sources is a serious problem.* Below is an example of the same lake taken in areal shots at two different times (the second may be during a drier season). The database modeler must make decisions about which source to follow in situations like this:



Contacts:

George Lukes (355-2818) is the manager of visual DB development operations.
Doug Carl (355-3714) has a mapping and image extraction background. He provided LandSat imagery, SPOT photos, tourist maps, etc.
Jay Banchero (355-3494) is a BBN modeler with art background. He has used S1000 for the last three years and is very familiar with database construction issues. He created a SIGgraph 88 piece in the Video Show.

Ellen Kay Project:

Ellen Kay is developing the process to import ITD data into the S1000 database environment. They will be using ArcInfo as an intermediate step. ETL is contracting the ITD work to Ellen Kay, currently they are not planning to develop the process themselves. Ellen Kay will be importing ITD for the Ft. Hood, Texas.

Using ArcInfo has an advantage because it imports and exports in ADWAMS format (a simple early GIS format which is pseudo-standard). Landsat, SPOT, and classified sources can all be supplied in ADWAMS format by a new photogrammetry station (DSPW) designed by General Dynamics. *Ray Green is familiar with this project. IST/VSL could substantially benefit by acquiring the DSPW workstation.*

The ITD data format:
Doug Carl, ETL, formerly with DMA, was active in the design of ITD data while at DMA. ITD is a vector-based data which takes the form of several separate files, each containing data from a single map overlay, i.e. one file for roads, one file for canals and rivers, etc. The user of the data must combine these separate files into a visual database. Power line and pipeline overlays are not included in ITD.

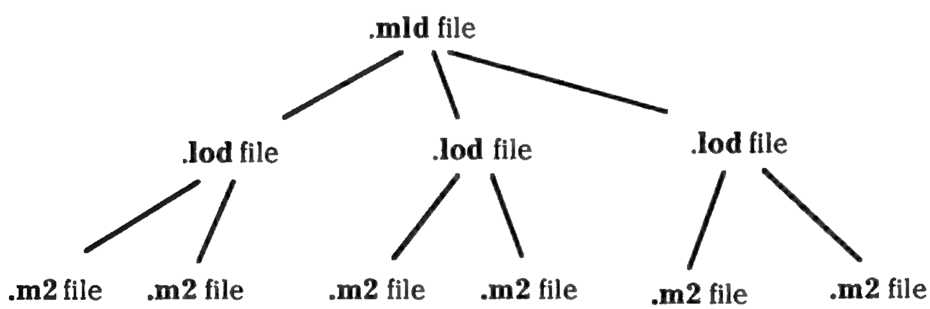
The vector data can carry any number of attributes belonging to two categories: descriptive (hard, soft) or numeric (10m high). The data is encoded in "standard linear format" in 40 byte blocks. Block types can be one of the following types:

DSI block	- header / table of contents packet
segment block	- coordinate value (a location)
feature	- feature data and attributes
text	- descriptive text for user info

The ITD format evolved because of the need for TTD (*Tactical Terrain Data*) to support military operations. TTD is very laborious to prepare and contains a HUGE amount of data. Doug Carl said a 15' x 15' cell took 2800-3200 hours to prepare by hand. The goal of ITD is to accelerate the preparation time. DMA would like to prepare TTD for battlefield areas, but it is Doug Carl's opinion that this may never be accomplished since it is a complex process.

S1000 Model Tool:

The file hierarchy of an articulated, multiple LOD file is shown below. The hierarchy is constructed by specifying linkages between the file types shown.



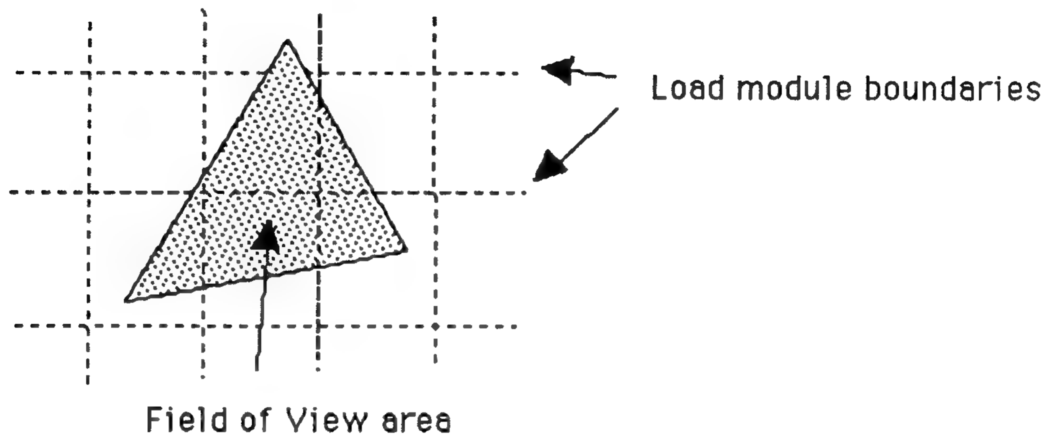
Naming Convention:
.m2 - Geometry files which are created to represent a single LOD for a polygonal model have the format "<modelname>_<revision>_<LODnum>.m2". For example, the file "bldg_hanger_a_1.m2" is the a-th revision of the LOD = 1 model for a hanger building.

.lod - This file contains the linkage hierarchy of separate ".m2" geometry files. Each file has a relative position offset.

.mld - multiple level of detail model file. This file contains pathnames which provide a linkage between the separate LOD files.

Polygon count guidelines:

Since the CIG pages the database in dynamic pieces called "load modules" while it is flying, a DB designer needs to be concerned only about the capacity of each load module (500 meters x 500 meters) and the overall capacity of the IG (around 1000 polygons), which could be viewing several load modules simultaneously:



The design guidelines we were given are as follows:

- 40 polygons/load module for static culture including buildings and networks (roads, rivers, etc).

- 32 polygons/load module for terrain

These limits, which seem quite low, allow for around 50 dynamic objects to be on the terrain in this load module without overloading the CIG capacity. Therefore, the capacity can be seen as

40 polys for culture
32 polys for terrain
1000 polys for models (50 models at 20 polys/model)

1072 polys total

For this scenario, it is obvious that the CIG can display only a single load module, but the terrain database is built to support LOTS of moving models over it's surface. The "simple terrain with gobs of moving models" method of terrain DB construction seems to be BBN's style of thinking. With the modelling performed at ETL, we could get

fairly dense looking cities because the underlying terrain was quite flat (needing only 1 or 2 polys for a 125x125 meter square).

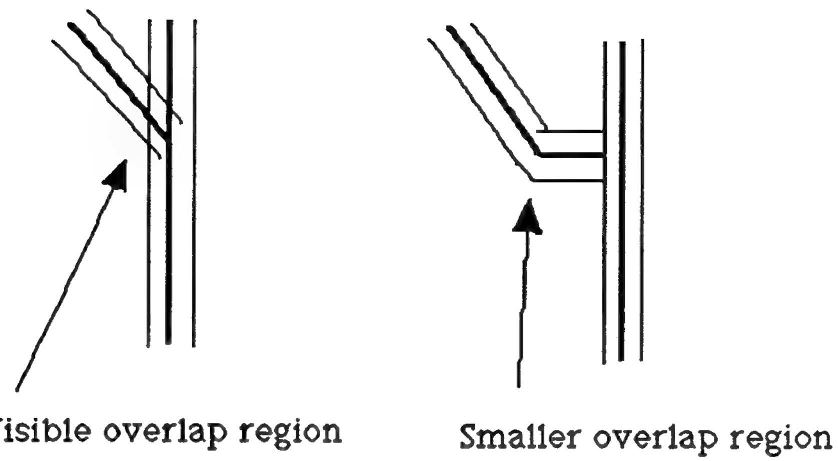
When designing multiple LOD models, the polygon count of the models should take into account the largest screen dimension possible on the CIG (640x480). If models don't cause an overload in this case, then they won't on smaller dimension channels either (like the M1 with its tiny channels!). The reverse condition is what causes a problem: a high polygon-count model could look allright on the M1 CIG but cause overload problems on a stealth vehicle with its larger channels.

S1000 Network Features:

Networks are added in the S1000 Assembly tool and are used to represent all roads and rivers, power lines, pipelines, and political boundaries.

Generic models, like power poles, are usually placed according to the networks in the database. This is currently a manual process where the modeler views the network vectors on the S1000 workstation and places generic models by eye near the network feature. Software is being developed to allow auto-placement of models along the network. This involves querying the network position and orientation, getting a distance between objects, and automatically placing them.

S1000 suffers from a limitation in mapping networks to polygons. Usually a textured polygon is repeated along the extent of a network. In the case of a road, the polygon has skid marks and a yellow line down the middle. The problem is encountered at the intersection of non-perpendicular networks. The polygons mapped to the network overlap as shown in the diagram below and create a noticable visual anomaly:

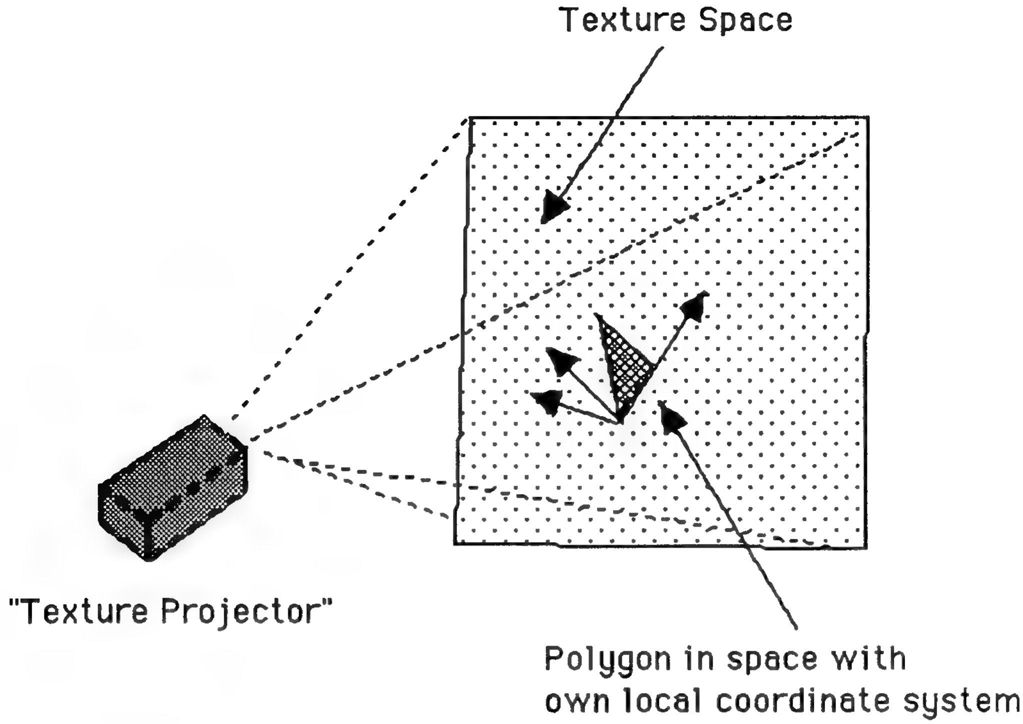


This problem is generally handled by forcing perpendicular intersections -- a process which must be done interactively by a modeler (time consuming for a large database).

Texture Mapping in S1000:

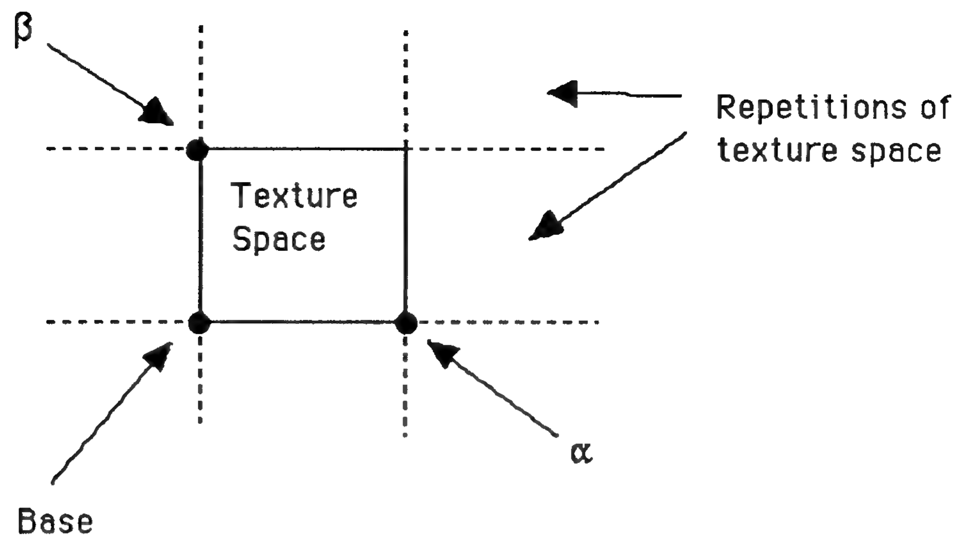
Each polygon in S1000 has the option of being assigned a flat RGB color or being textured with a pre-loaded texture pattern. the S1000 texture patterns are color maps with 4-bit intensity values. When a colored texture pattern is applied, the polygon automatically takes on the color and intensity of the pattern. This works differently than the standard black & white texture method where the texture map is treated as an intensity and only varies the color already given separately to the polygon. The black & white method is used in the GE Compuscene-IV, E&S-500, and Redifusion's CT-5, CT-6 (also made by E&S).

Texture mapping is accomplished in the S1000 system by defining a hypothetical texture space. A textured polygon or group of polygons can be placed inside this space and they will acquire whatever texture is projected upon them.



This can best be visualized by the above diagram where the texture map is projected onto a far wall. Any textured polygons can be inserted anywhere in the projection pyramid and oriented as desired. The orientation and size of the texture space is defined first by picking 3 points in world coordinates to define the corners of the base of the texture space (referred to as the "base", α , and β points). This becomes the "current" texture space and is mapped onto any number of polygons desired. The texture space can be redefined any time a modeler desires. Normally the texture space is defined once for each set of parallel polygons so no scew effect is visible.

The texture space can be considered infinitely repeating. If a polygon is outside of the shown pyramid, it will acquire the texture according the repeating of the texture space (sort of like a 3D modulus operation).



A SIMNET CIG hardware limitation exists allows for only **four** repetitions of the texture space. Therefore, the most you can make is four copies of a texture map along any axis in texture space. Restated, a polygon on the CIG can never have a texture pattern repeat more than four times in either axis (a square could have 4 x 4 for 16 total patterns).

GIS History and Issues:

George Lukes believes (and I agree) that a terrain database system must manage its information in a GIS-like way. This means the database system should:

- Allow multiple input sources (images, maps, etc.)
- Provide a means of adding attributes (material, hardness, etc)
- Have a flexible interior data structure which supports vector data (roads, pipelines) and also handles polygons for the IG.
- *Support both mapping (cartography) and CAD (computer graphics) applications.*

Integraph tried several years ago to incorporate both CAD and mapping technology in a project called TIGris (sp?) or Mini-TOPO.

This was supposed to be a three dimensional GIS system. According to George Lukes, it never succeeded because it was too ambitious.

ADWAMS is a simple GIS format originally developed to represent wetlands in the US (by the Forestry service?). It was originally composed of two separate projects: a mapping system called MOSS and a digitizing and importing system called AMS. Since it is a simple format, it is a defacto standard for data interchange between GIS systems. ADWAMS supports points and triplets with attributes, strings of features, and outputs in a polygonal representation. ARCINFO imports/exports this format.

ArcInfo is a traditional GIS program which has previously been used on several Army programs and has a following of users. It is a good choice of GIS primarily because it is established in the industry. It does not address the powerful merging of map (2D) and CAD (3D) information particularly well.

DSPW is a photogrammetry station developed by General Dynamics (referred to during the section on the Ellen Key project). This station is composed of photogrammetric and GIS software running on a Sun-4 platform. It is designed in a modular style with a suite of tools to import data from Landsat, SPOT, ArcInfo, and ADWAMS sources. It also imports from several classified sources. *George Lukes informed me that Ray Green knows about this station and is interested in getting this for IST/VSL, but we need to acquire someone with photogrammetry and cartography background before we could use it.*

Conclusion:

I received training on the BBN S1000 tools and learned about BBN's database development process through discussions with Jay Banchero. I was made aware of some of the cartographic issues which need to be addressed during database construction by the ETL employees.

This was a useful trip because of both the S1000 training and the beginning of cooperation between IST/VSL and ETL.

First Yearly Report

On

Recovery of 3D Information Using Stereo *

Vineet Goel and Mubarak Shah

Computer Science Department

University of Central Florida

Orlando, FL 32816

January 13, 1991

*The research reported here was supported by PMTRADE/IST. The content of the information herein does not necessarily reflect the position or the policy of the government, and no official endorsement should be inferred.

Contents

1 Introduction

The goal of the stereo vision is the recovery of three- dimensional information from images taken from different viewpoints. Two cameras located at two positions can be used to take two images, or one camera can be used to take two images from two different positions. As one takes images of an object from two different positions, the object is shifted in one image relative to that in other image. This shift is inversely proportional to the depth of the object, which is the distance of the object from camera. We call this shift disparity, and hence it is the measure of three dimensional depth.

The basic problem in stereo is that, one has to match a point from the left image to a point in the right image. One point in the left image can correspond to only one point in the right image. The problem of matching a point from left image to a point in the right image is called correspondence problem. All the stereo algorithms try to solve this problem.

If we take two images with the cameras which are aligned, the matching problem can be restricted to one dimensional search along any row, i.e. we do the matching of the points in the same row in both images, we don't match a point in one image to the point in other image which is not in the same row. This constraint is known as *epipolar constraint* .

Establishing correspondence problem is the main task in a stereo algorithm, this involve two questions: what to match? and how to match? Correspondence between two images can be established by matching specific features such as blobs or edges, or by matching small regions by direct correlation of image intensities without identifying features. After feature matching, the next step in stereo is to apply continuity constraint, which states that *disparity varies smoothly almost everywhere, and that only a small fraction of the area of an image is composed of bounderies that are discontinous in depth* . When disparities at some points are not known, a surface between known disparities can be interpolated using the smoothness criterion. Since these disparities are direct measure of the depth, we can interpolate a surface going through all points with given disparities.

This report summarizes our work during the first year of this project. The first six months of this project were devoted to the literature search on the stereo algorithms. A number of recent papers from the current literature were studied and their approaches analyzed. Three representative algorithms were selected for further study. During the next six months

the algorithms were implemented, and tested on a representative set of stereo pairs. This report describes our experiments, and the comparitive study of these algorithms. During the second year of this project we will focus on improving these algorithms by incorporating the smoothness and continuity criteria. We will also attempt to introduce some other 3D cues like *shading* in the stereo algorithms. It is expected that the performance of such method using multiple cues will be much better than the one using only single cue. We will also start an initial study related to interpolation of surface from the dispariy maps.

In the next section, we will discuss three stereo algorithms : Normalized Correlation Method, Difference Method and Prazdny's Method. Section 3 presents the results obtained for several images with these algorithms. We end this report with section 4 which conclude this report. We have also included the source codes of three algorithms, and Canny's edge detector written in C language in the Appendix A. This will make it easy to run these algorithms on any other system for further experimentation. In addition, the demos for running our programs are given in the Appendix B.

2 Algorithms

The three algorithms which are used here, basically try to match corresponding points in images and get the difference in their positions, which as explained in previous section is measure of the distance of a point in the object from camera. Cochran and medioni [2], have proposed an algorithm which declares a point as corresponding point to a ipoint at which highest Normalized correlation is obtained. The algorithm reported by Kayalap [3], takes sum of the absolute difference of the intensities of the neighbouring points of a point in the left image to the corresponding neighbouring points of a point in the right image. The point in the right image, which gives the minimum sum of difference, is the matching point. Prazdny's [1] algorithm chooses a matching point which gets the maximum support from its neighbours.

Each of the algorithm is discussed briefly in the following sections.

2.1 Normalized Correlation Method (Cochran and Medioni)

In this method, to match a point x in the left image to the point y in the right image, we first get the mask of given size around x. Then we compute the normalized correlation of that mask with the mask around point y in the right image. The point y at which we get the maximum normalized correlation value is the matching point. The difference in the position of x and y is the disparity value for x. If multiple points with maximum normalized correlation values are obtained, we select one disparity value for the point x, based on the smoothness criterion. The smoothness criterion assume that a point x has almost the same disparity value as of its neighbouring points. Finally, the edgels from the original intensity images can be extracted, and used for possible locations of the depth discontinuties.

In order to get disparity for a point (x, y), we compute

$$A(x_i, y) = \sqrt{\sum_{j=-m}^{m} \sum_{k=-m}^{m} R(x_i + k, y + j)^2}$$

$$c(x_i, y) = \frac{\sum_{j=-m}^{m} \sum_{k=-m}^{m} L(x + k, y + j) \times R(x_i + k, y + j)}{A(x_i, y)}$$

where

$$x - d \leq x_i \leq x + d,$$

d is the disparity, m is the mask size, $L(x, y)$ and $R(x, y)$ respectively are the gray values in left and right image at (x, y). The point (x_i, y) at which value of $c(x_i, y)$ is maximum is the matching point for (x, y), and $x_i - x$ is the disparity value for (x, y).

2.2 Sum of Absolute Difference Method (Kayalap)

This method is based on sum of absolute differences of intensity values around the small neighborhood of the two points in the left and right images. To get a point y in the right image corresponding to the point x in the left image, first the mask of given size around x is obtained. Then the sum of absolute differences (SAD) of this mask with the mask centered around point y in right image is computed. The point in the right image which has minimum SAD is the point y matched to the point x in the left image. The difference in the position of x and y is the disparity for x. The disparity for all the points in the left image are computed

in the similar fashion. In this case also, we may get multiple points with the same SAD for a point x. The smoothness criterion can be used to to resolve the disparity conflict.

The disparity for a point (x, y) is computed as follows:

$$D(x_i, y) = \sum_{j=-m}^{m} \sum_{k=-m}^{m} | L(x+k, y+j) - R(x_i+k, y+j) |$$

where

$$x - d \leq x_i \leq x + d,$$

d is the disparity and m is the mask size. The point (x_i, y) at which the value of $D(x_i, y)$ is minimum is the matching point and, $x_i - x$ is the disparity value for (x, y).

2.3 Prazdny's Method (Prazdny)

In this method, the disparity is computed at edge points only unlike the previous methods where the disparity was computed for each point. Therefore, the first step in this method is to apply the edge detector to left and right images. Prazdny's method is based on smoothness criterion. The point under consideration should have the same disparity value as of most of its neighbours. This implies that the neighbours should support a disparity value for a point under cosideration. Prazdny has given an expression which calculates support for a disparity value of a point based on above criterion. This expression is called similarity function. The sum of similarity function for each possible disparity is calculated. A final disparity value for which this summation is maximum is assigned to the point.

The similiarity function should meet three requirements :

1. The disparity similarity function should be inversely proportional to the difference of disparities of interacting points.

2. More distant points should exert less influence while nearby points should have more disambiguiting power.

3. The more distant the two interacting points are the less seriously should their disparity difference be considered. Because of inherent uncertainity : steeply-sloped surfaces will generate large disparity differences which should nevertheless contribute to disambiguation. For large seperations one should probably expect a flat support function.

The similarity function capturing all of these requirements is :

$$s(i,j) = \frac{e^{-(D_i - D_j)^2/(2c^2(i-j)^2)}}{c \mid i-j \mid \sqrt{2\pi}}$$

Here, $s(i,j)$ expresses the amount of support disparity D_i at point i, receives from disparity D_j at another point j, and $\mid (i-j) \mid$ is the distance between two points, c is scaling costant, usually taken between 0.55 and 0.85.

The first step in this method is to compute all the potential disparities for each point in the left image. We will explain this step by taking an example in one dimension. This example can easily be extended to two dimensions.

Let $\otimes$ denote exclusive nor operation, and let two one dimensional images of size 1×5 are

left(L) image

0	1	1	0	0

Right(R) image

0	0	1	1	1

then C^0 is defined as:

$$C^0(x,d) = L(x) \otimes R(x+d)$$

For this example the initial disparity map, C^0 is given by:

	1	**2**	**3**	**4**	**5**
2		1	1		
1	1	1	1		
0	1		1		
-1					
-2				1	

The first column (shown in bold) represents possible disparity values ranging from -2 to $+2$ in this case. While the first row (shown in bold) denotes the x location of a point.

The disparity values influence each other as follows. Suppose that a left image feature point at location i has a set of possible disparities D_i and we are interested in the amount of support a particular disparity d_i receives from the feature point j (with possible disparity set D_j), which is neighboring point of i. First, the disparity d_j from set D_j of point j is selected, and the support is computed using similiarity function. In the same way, the support for a disparity value d_i is computed using all disparity values d_j of all neighbors j of point i. Then all these supports are added to get the support for disparity d_i of point i. The disparity d_i for point i which receives the maximum support is the final disparity value assigned to the point i.

3 Results

The algorithms discussed in the previous sections were tested on a set of six stereo pairs: Renault, Sandwich, Pentagon, Sphere, Ruts, and Rocks. The Renault pair shows the auto part used in the Renault car, while the Sandwich pair shows a Sandwich resting on a flat surface, and the Pentagon pair is an aerial view of the Pentagon with some cars in the parking lot in the background. The Sphere pair is synthetically generated which shows a concrete shpere on the table. Finally, the Ruts and Rocks pairs are real images which show respectively the mound of rocks, and ruts. The images were acquired from Professor Ramesh Jain at University of Michigan, Ann Arbor. The original images were of the size 512×512, but were reduced to 128×128 for timing constraint. All the algorithms were run on Sun SparcStation-1.

3.1 Normalized Correlation Method

The results are shown in Figures 2–7. The informations regarding the image size, disparity range, masksize and cpu time in seconds are given in the table shown in Figure 1.

Disparity map for the Sandwich image shown in Figure 3(c), is almost continouous on the surface of sandwich. There is some discontinuity which can be avoided by using continuity criterion. In case of Pentagon image shown in Figure 4, it was observed that smaller mask size gave rise to the finer details of the Pentagon building. However, lot of discontinuities in the background were also observed. On the other hand, with large mask size the finer details were lost but background became smoother. Disparity map for Renault shown in Figure 2(c) does not have much discontinuity on the surface of Renault, and for larger mask the background is smoother also. The disparity maps for Sphere, Ruts and Rocks shown in Figure 5(c), 6(c) , 7(c) respectively, are not of good quality. It is difficult to perceive anything significant from disparity maps of Ruts and Rocks. The input images themselves are very difficult to analyze, these images have lot of symmetry. In this case, when selecting a particular disparity value the algorithm encourages multiple matches. Therefore, the results are not good.

Figure	*Image*	*Size*	*DisparityRange*	*Masksize*	*Time(sec)*
2	*Sandwich*	128×128	13	11	782
3	*Pentagon*	128×128	4	11	257
4	*Renault*	128×128	10	11	609
5	*Sphere*	128×128	17	11	2114
6	*Ruts*	128×128	17	11	1004
7	*Rocks*	128×128	38	11	2049

Figure 1: Summary of result for Normalized Correlation Method.

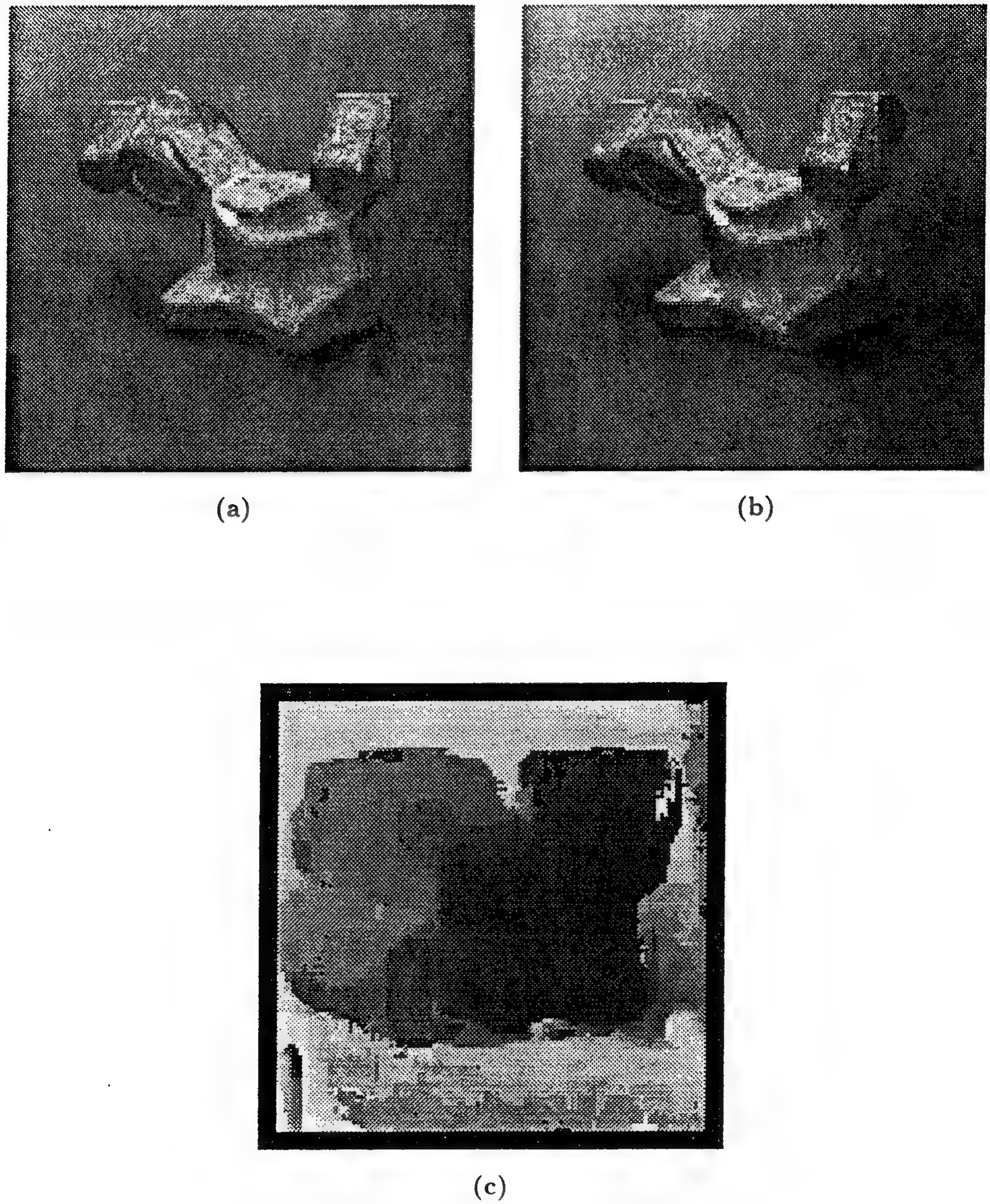


Figure 2: Result of Normalized Correlation Method for Renault Image. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.

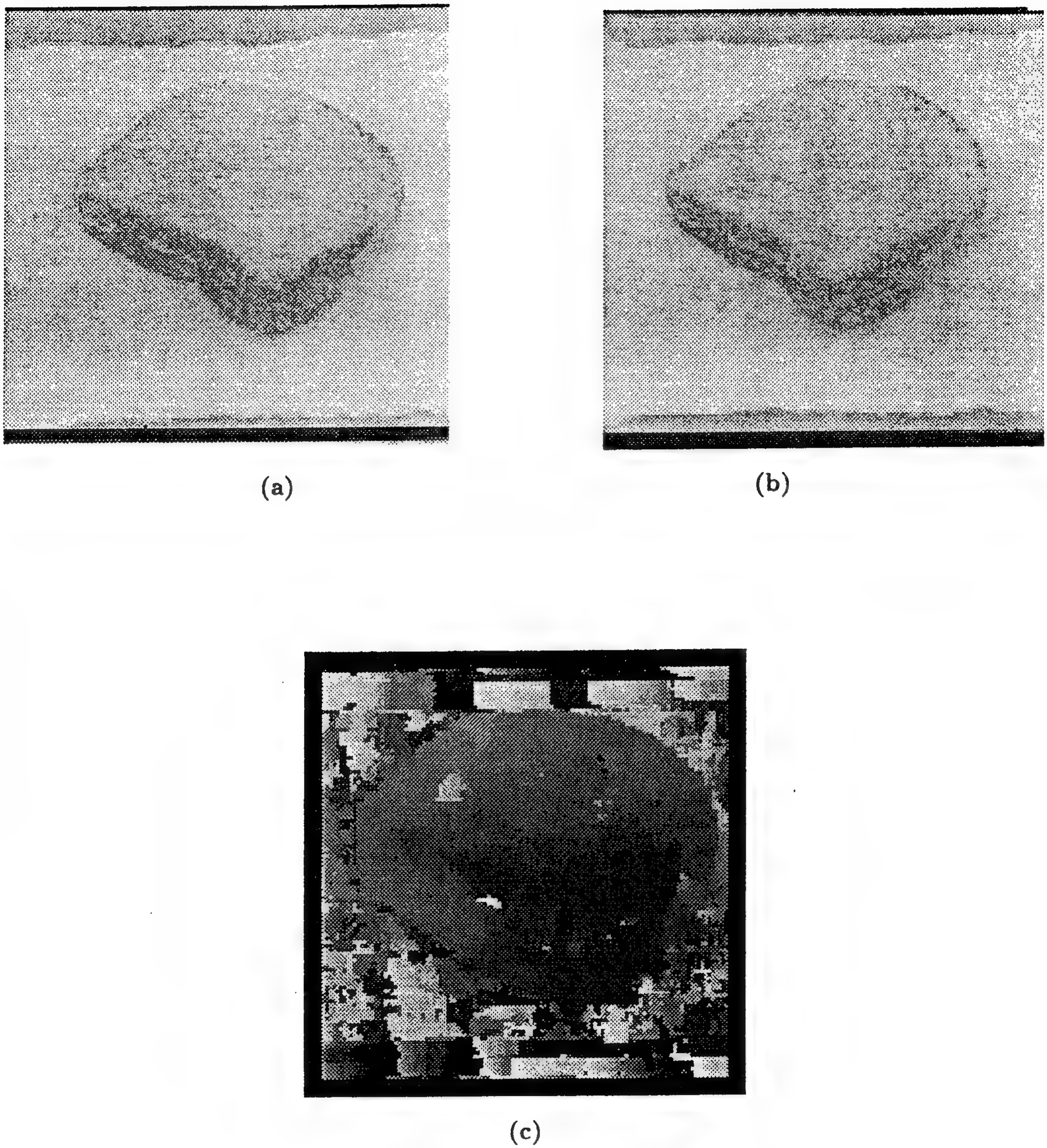
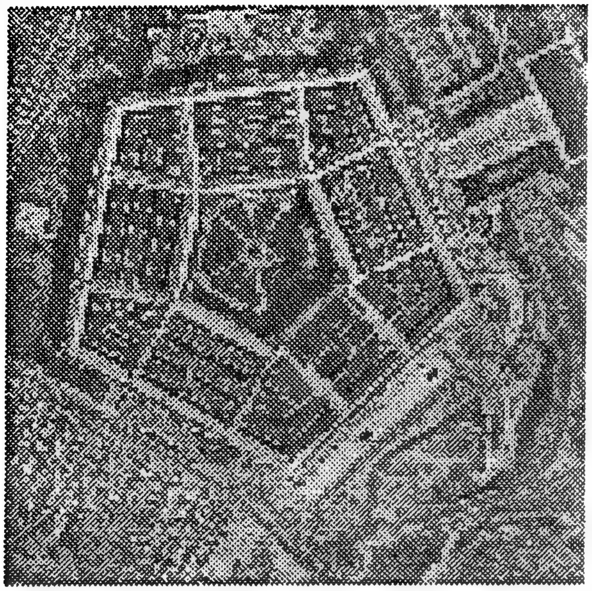
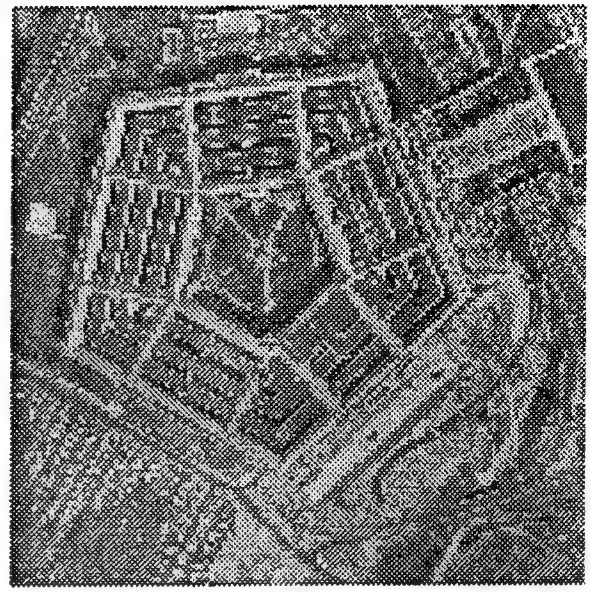


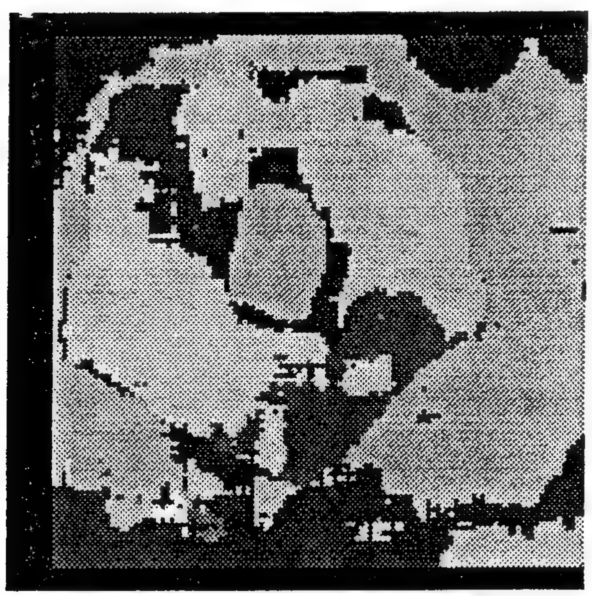
Figure 3: Result of Normalized Correlation Method for Sandwich Image. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a)

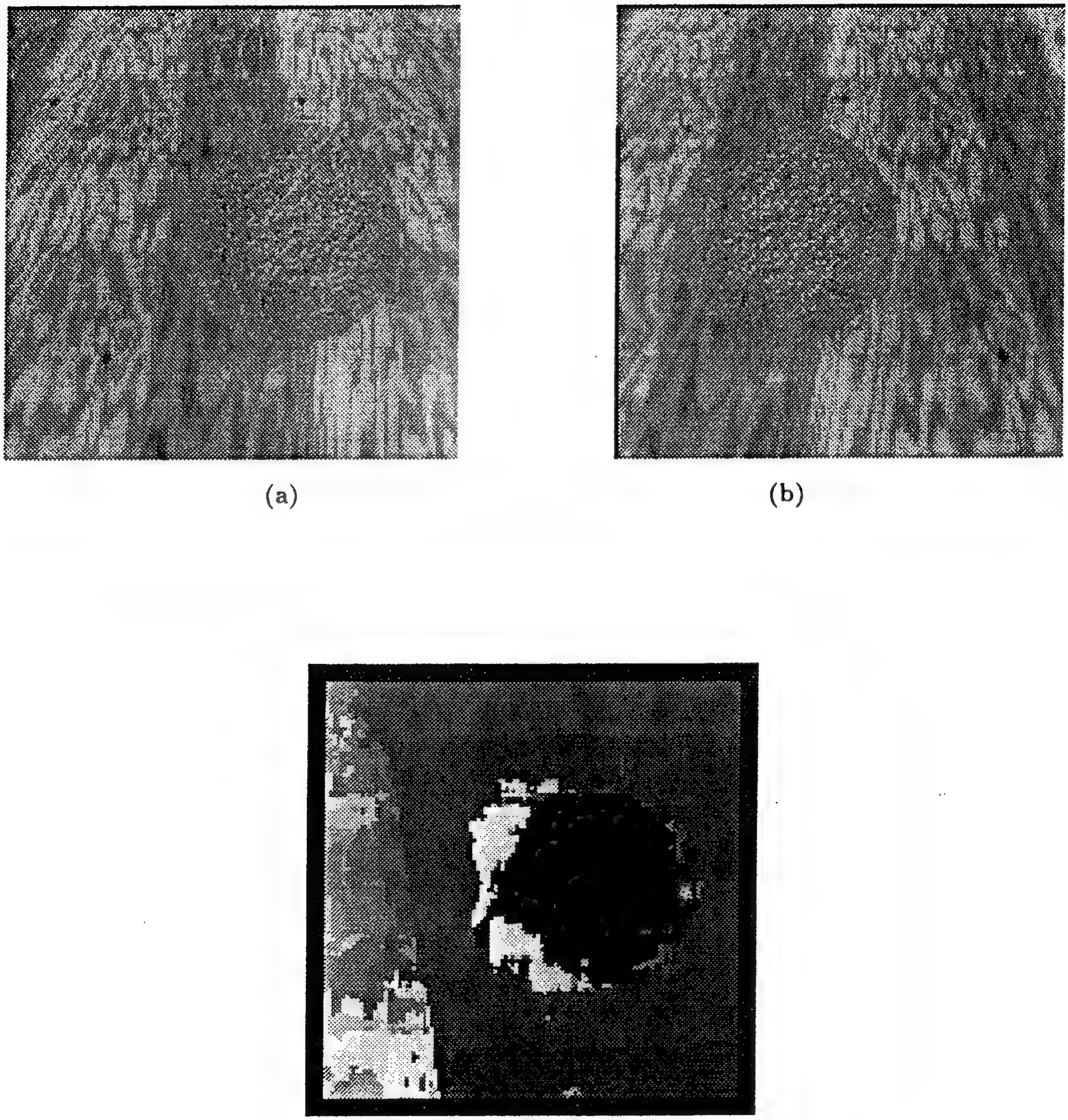


(b)



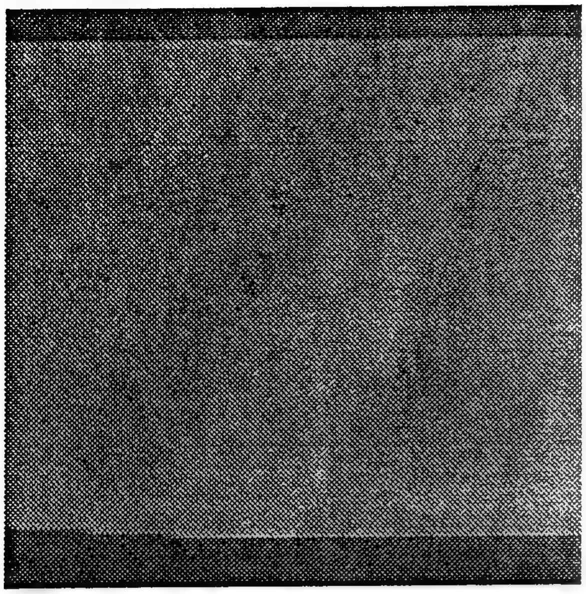
(c)

Figure 4: Result of Normalized Correlation Method for Penatgon Image. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.

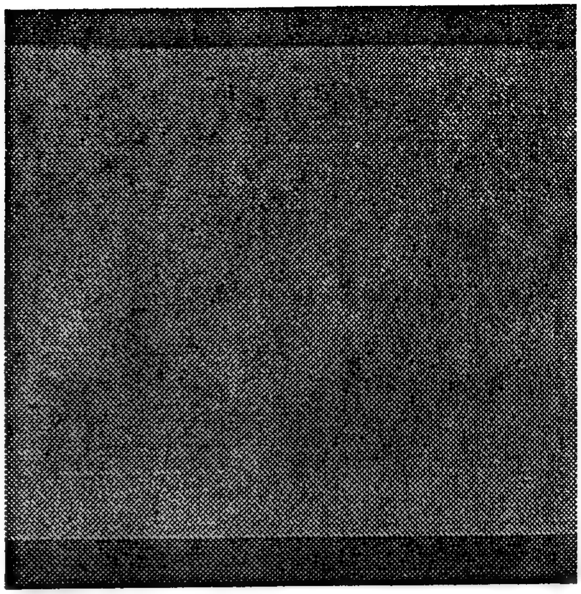


(a) (b) (c)

Figure 5: Result of Normalized Correlation Method for Sphere. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



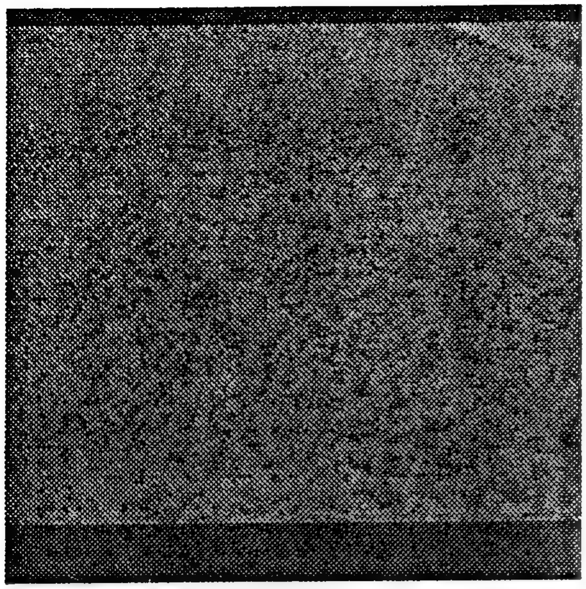
(a)



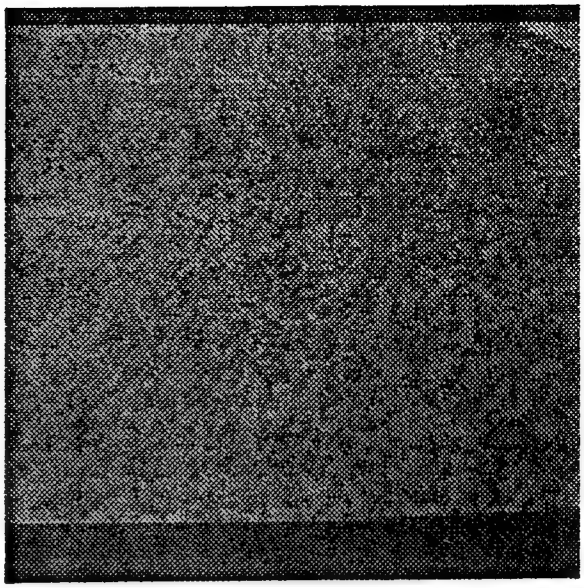
(b)

(c)

Figure 6: Result of Normalized Correlation Method for Ruts. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a)



(b)

(c)

Figure 7: Result of Normalized Correlation Method for Rocks. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.

3.2 Difference Method

The results for this method are shown in Figures 9–14. The informations regarding the image size, disparity range, masksize and cpu time in seconds are given in the table shown in Figure 8.

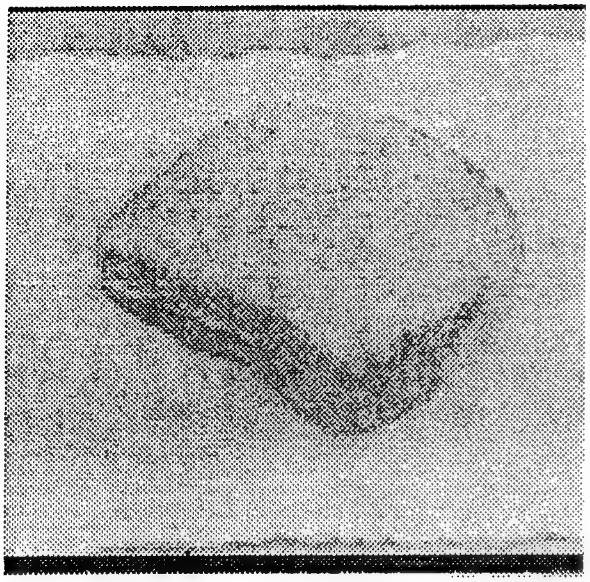
The disparity map for the Sandwich pair is shown in Figure 9(c). It is clear from the result that some of the details are missing, which can be filled in using the continuity criterion.

The disparity map for the Pentagon pair shown in Figure 10(c) does not contain finer details. The results for the Sphere pair shown in Figure 12(c) are very good with this method. The sphere is clearly visible.

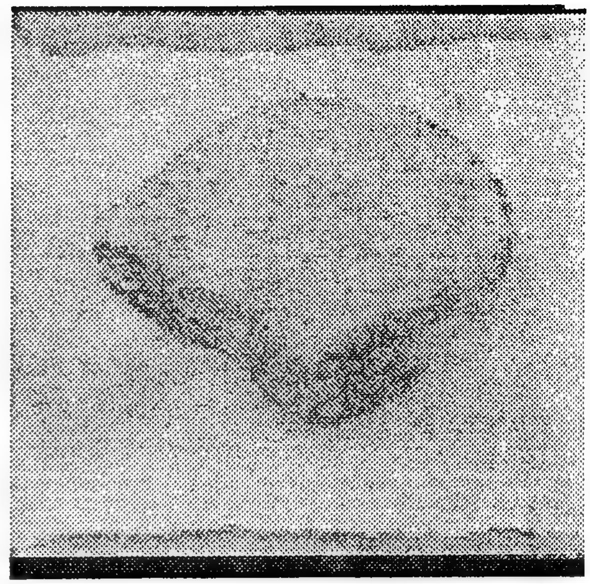
In summary, we get almost similiar results with this method as compared to the the correlation method discussed in the previous section. However, the difference method is the order of magnitude faster than the normalized correlation method. The normalized correlation method requires additional square root operation for each point, which slows it down.

Figure	*Image*	*Size*	*DisparityRange*	*Masksize*	*Time(sec)*
8	*Sandwich*	128×128	13	11	327
9	*Pentagon*	128×128	4	11	122
10	*Renault*	128×128	10	11	261
11	*Sphere*	128×128	17	11	391
12	*Ruts*	128×128	17	11	411
13	*Rocks*	128×128	38	11	800

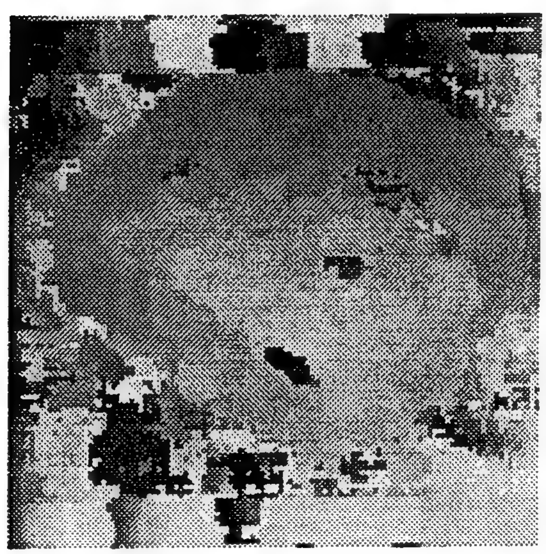
Figure 8: Summary of Results for Difference Method.



(a)

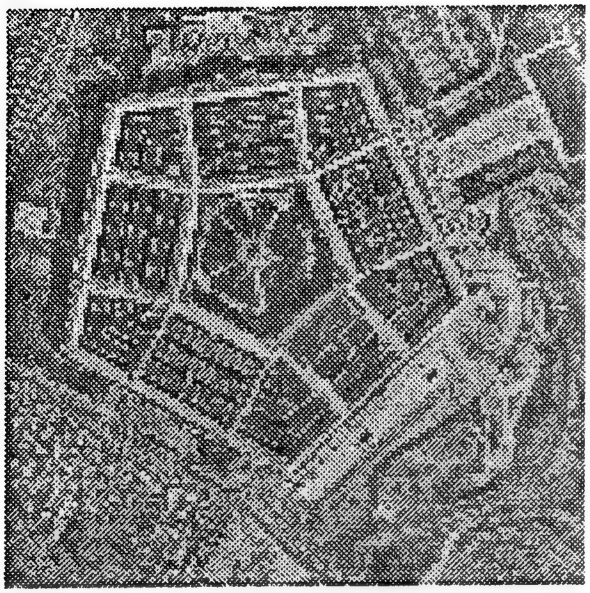


(b)

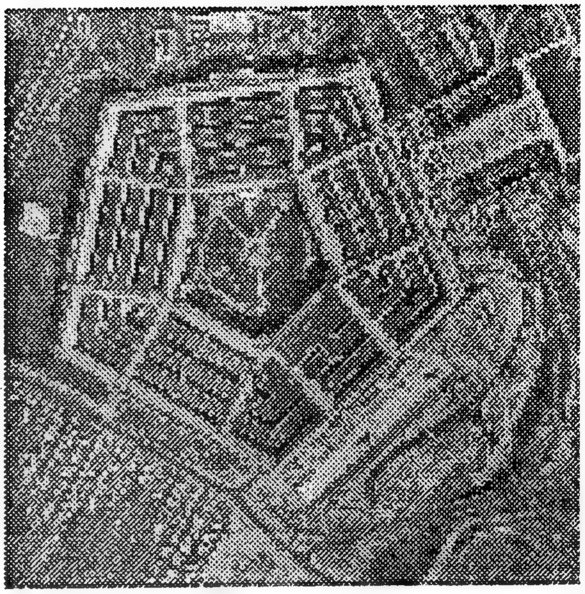


(c)

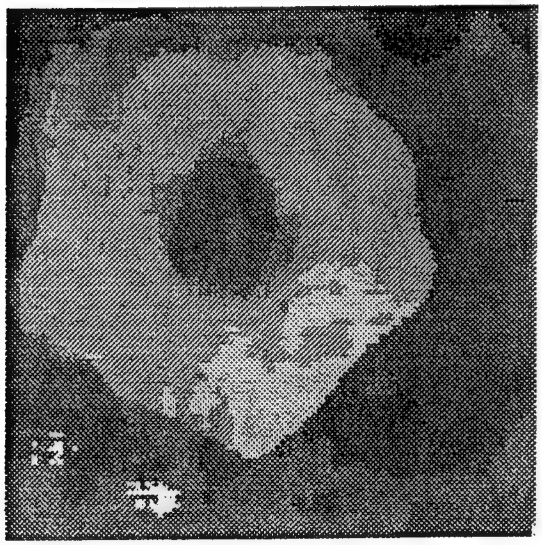
Figure 9: Result of Difference Method for Sandwich. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a)

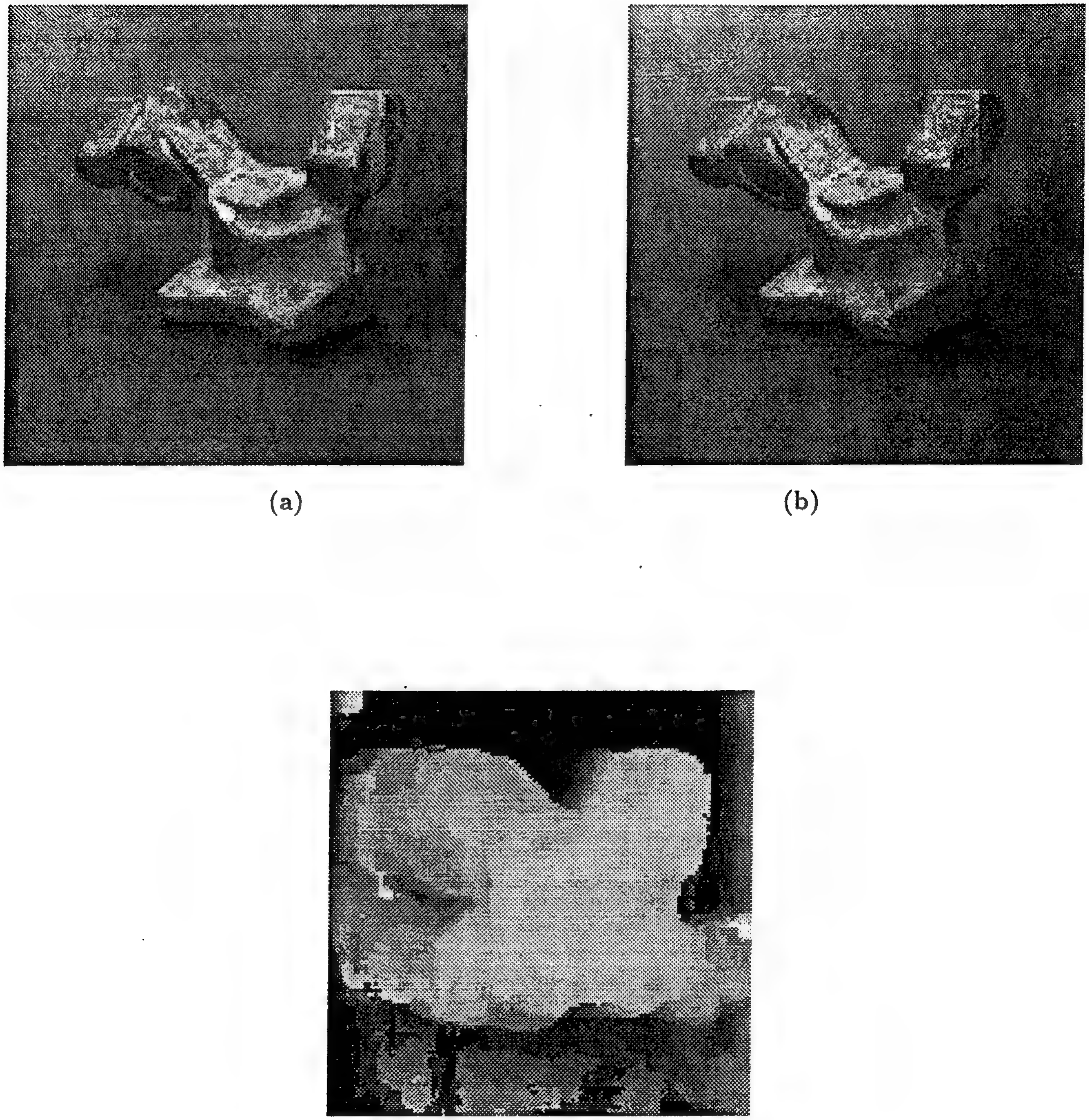


(b)



(c)

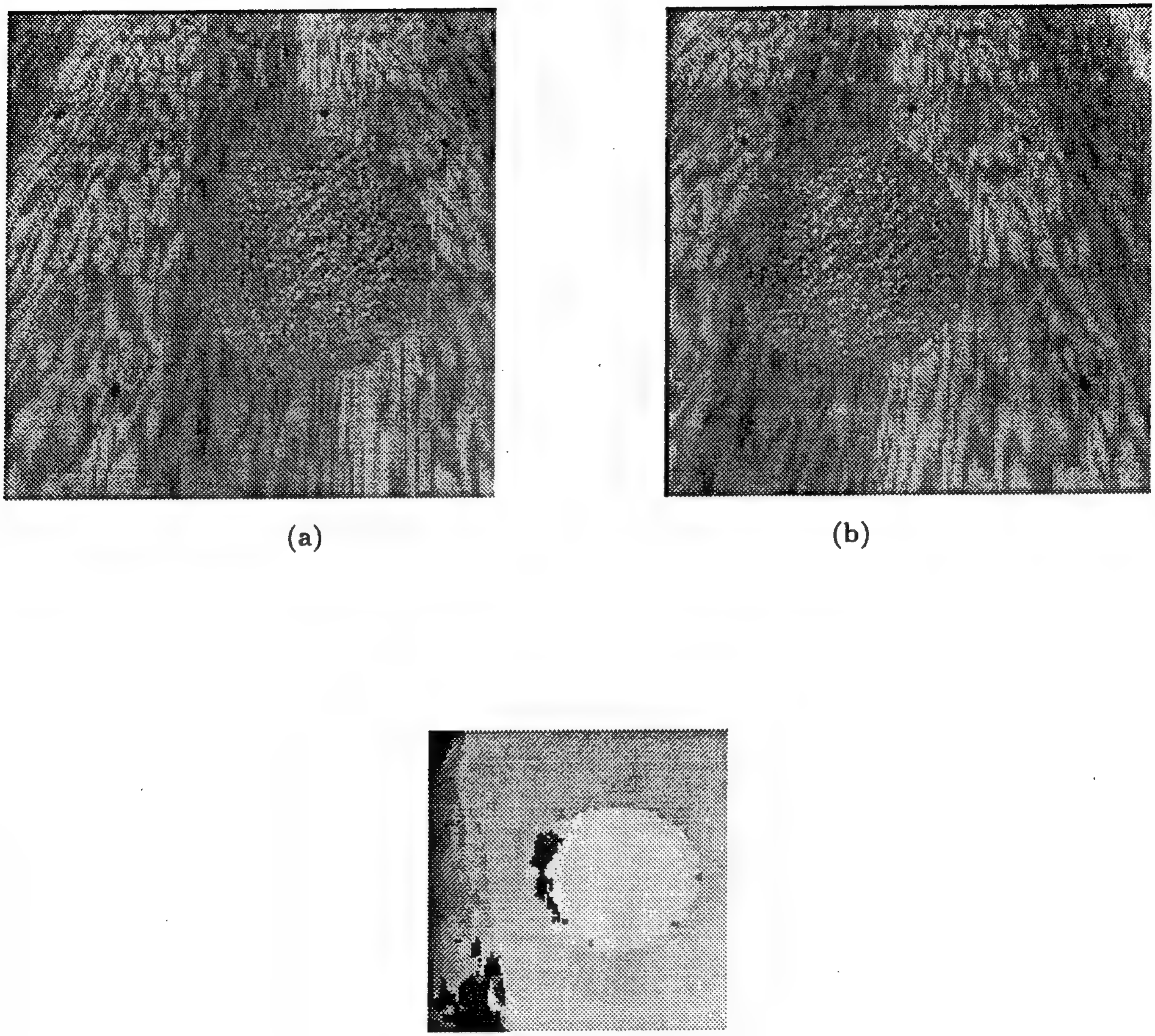
Figure 10: Result of Difference Method for Pentagon. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a) (b)

(c)

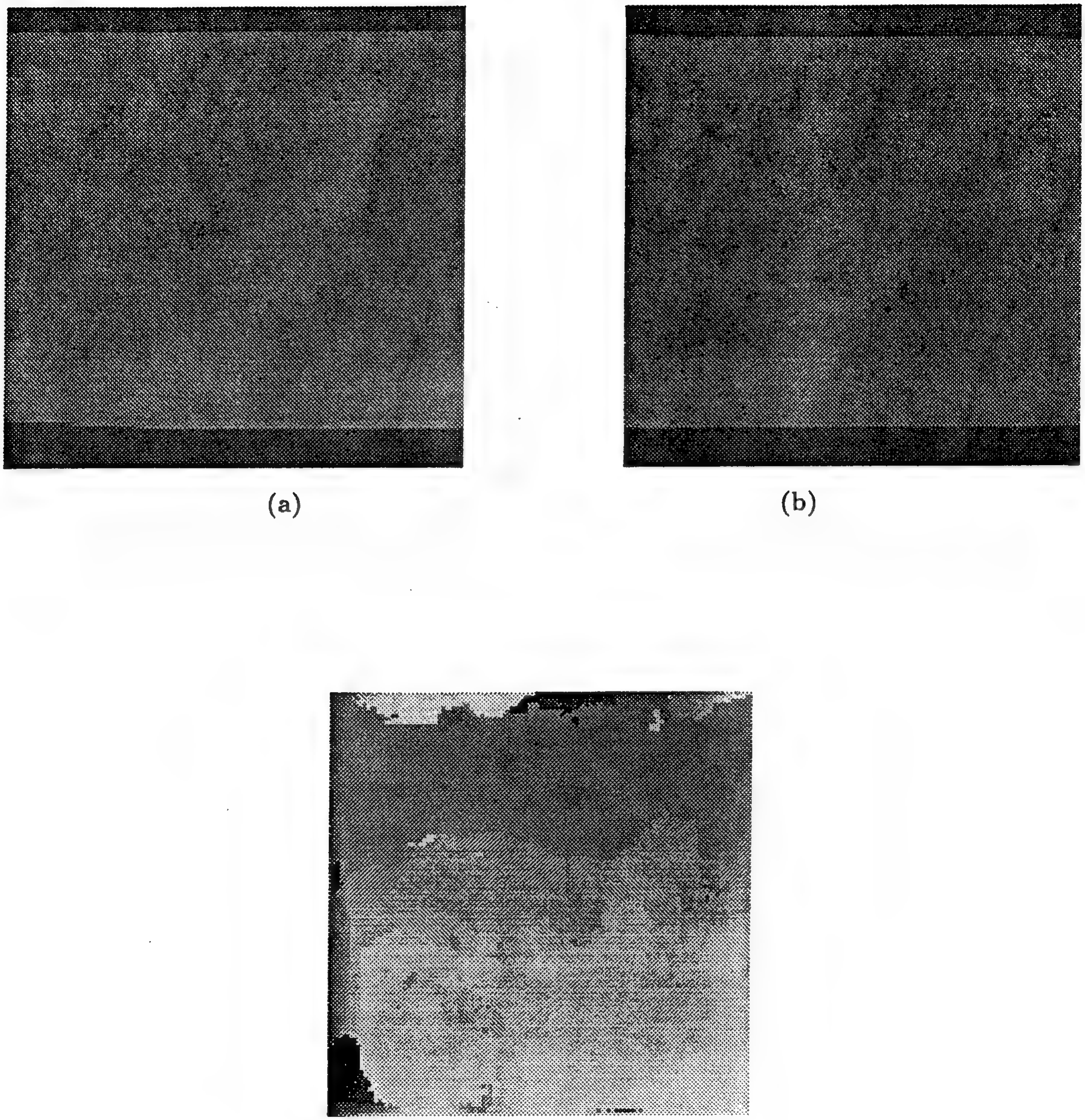
Figure 11: Result for Difference Method for Renault. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a) (b)

(c)

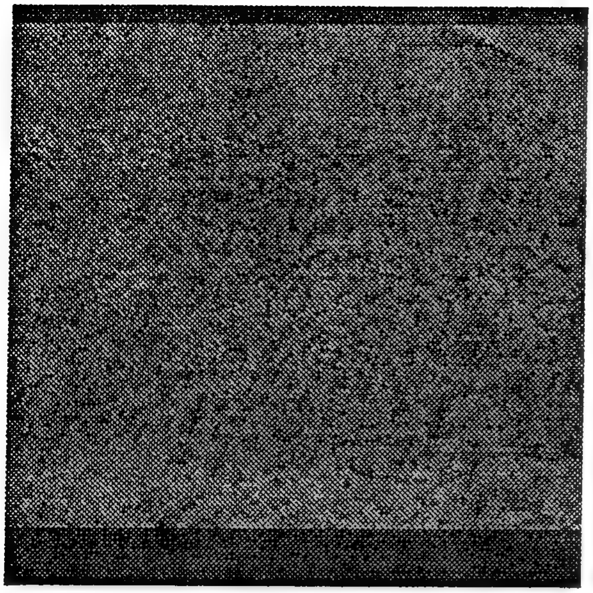
Figure 12: Result for Difference Method for Sphere. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



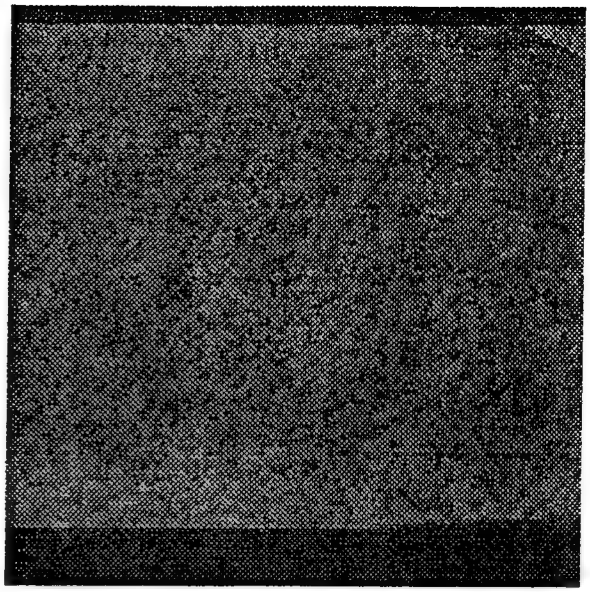
(a) (b)

(c)

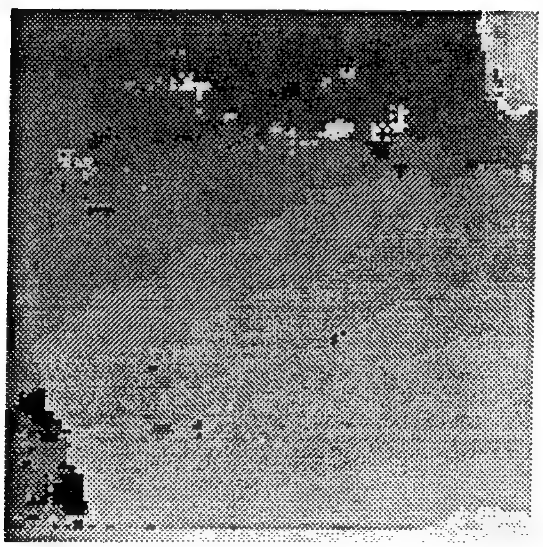
Figure 13: Result for Difference Method for Ruts. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.



(a)



(b)



(c)

Figure 14: Result for Difference Method for Rocks. (a) Left Image, (b) Right Image, (c) Disparity Map. Darker parts are closer to the viewer.

3.3 Prazdny Method

The results obtained with Prazdny's method are shown in Figure 16–21. The informations regarding the image size, disparity range, masksize and cpu time in seconds are given in the table shown in Figure 15. The value of constant c in the similiarity function is taken as 0.65. Canny's edge detector was applied to get the negative and positive edges for all the images.

The left and right images for the Sandwich pair are shown in Figures 16 (a)-(b), corresponding edge maps are shown in Figure 16(c)-(d), and the disparity map is shown in Figure 16(e).

The results for the Pentagon pair are shown in Figure 17. The disparity map obtained for this pair is quite good. The disparity map for Renualt pair is shown in Figure 18(e).

Next, the results for the Sphere pair are shown in Figure 19. From the edge maps of this pair, it was observed that disparity for this pair is very high. Therefore, a high disparity value range was given as input to the algorithm. The benefit of edge based method is that, we can easily observe from edge map what maximum disparity value is to be given as input. For this pair we get much better result as compared to methods discussed in previous subsections.

Quite good results were obtained with this algorithm for Ruts and Rocks stereo pairs shown in Figures 20 and 21(e) respectively, as compared to previous two methods.

Figure	*Image*	*Size*	*DisparityRange*	*Masksize*	*Time(sec)*
16	*Sandwich*	128×128	13	11	16
17	*Pentagon*	128×128	4	11	19
18	*Renault*	128×128	10	11	65
19	*Sphere*	128×128	13	11	29
20	*Ruts*	128×128	13	11	16
21	*Rocks*	128×128	13	11	18

Figure 15: Summary of results for Prazdny's Method.

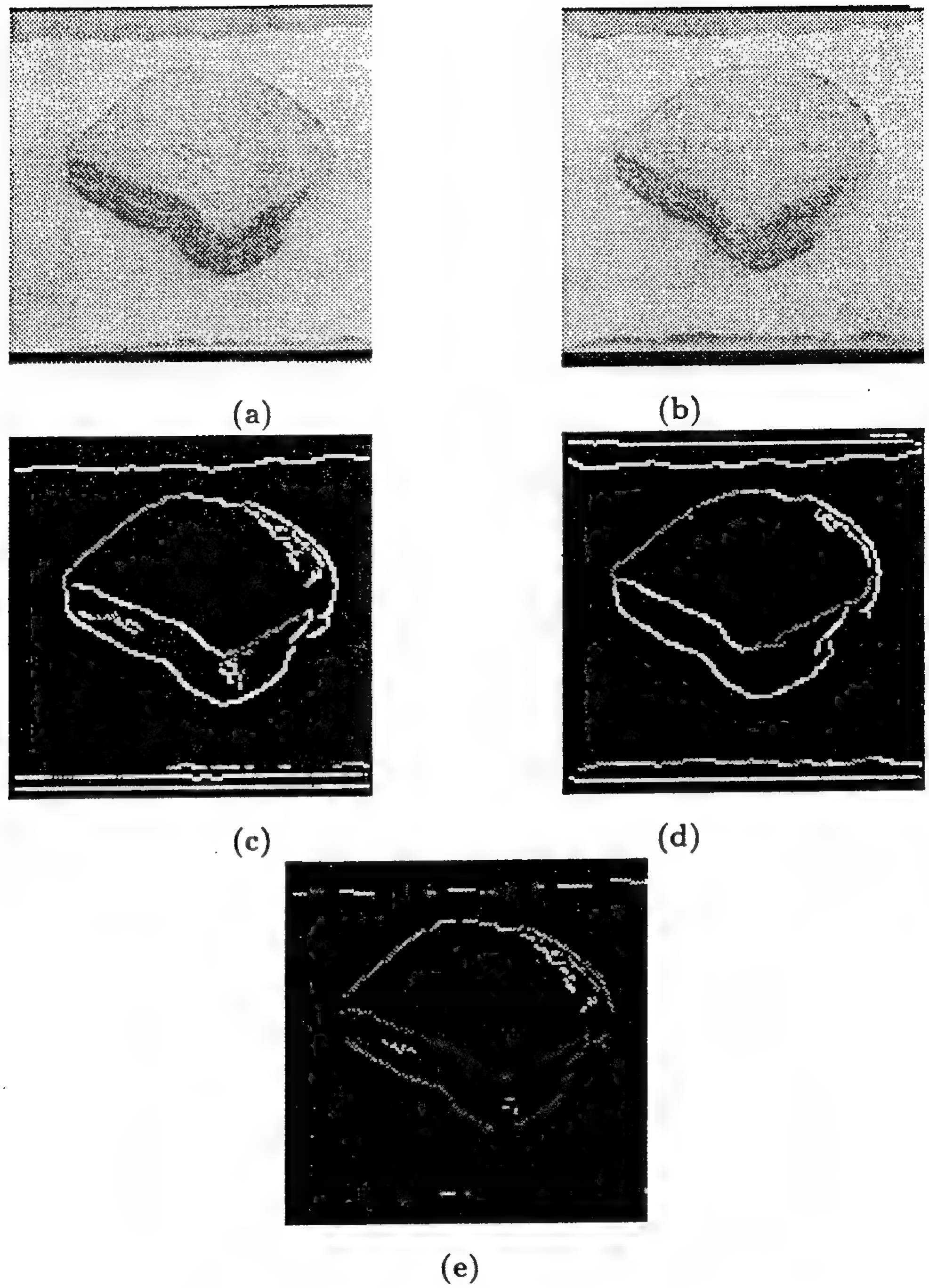


Figure 16: Result for Prazdny's Method for Sandwich pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edges are brighter than negative edges. (e) Disparity Map at edge points only. Brighter edges are far from the viewer.

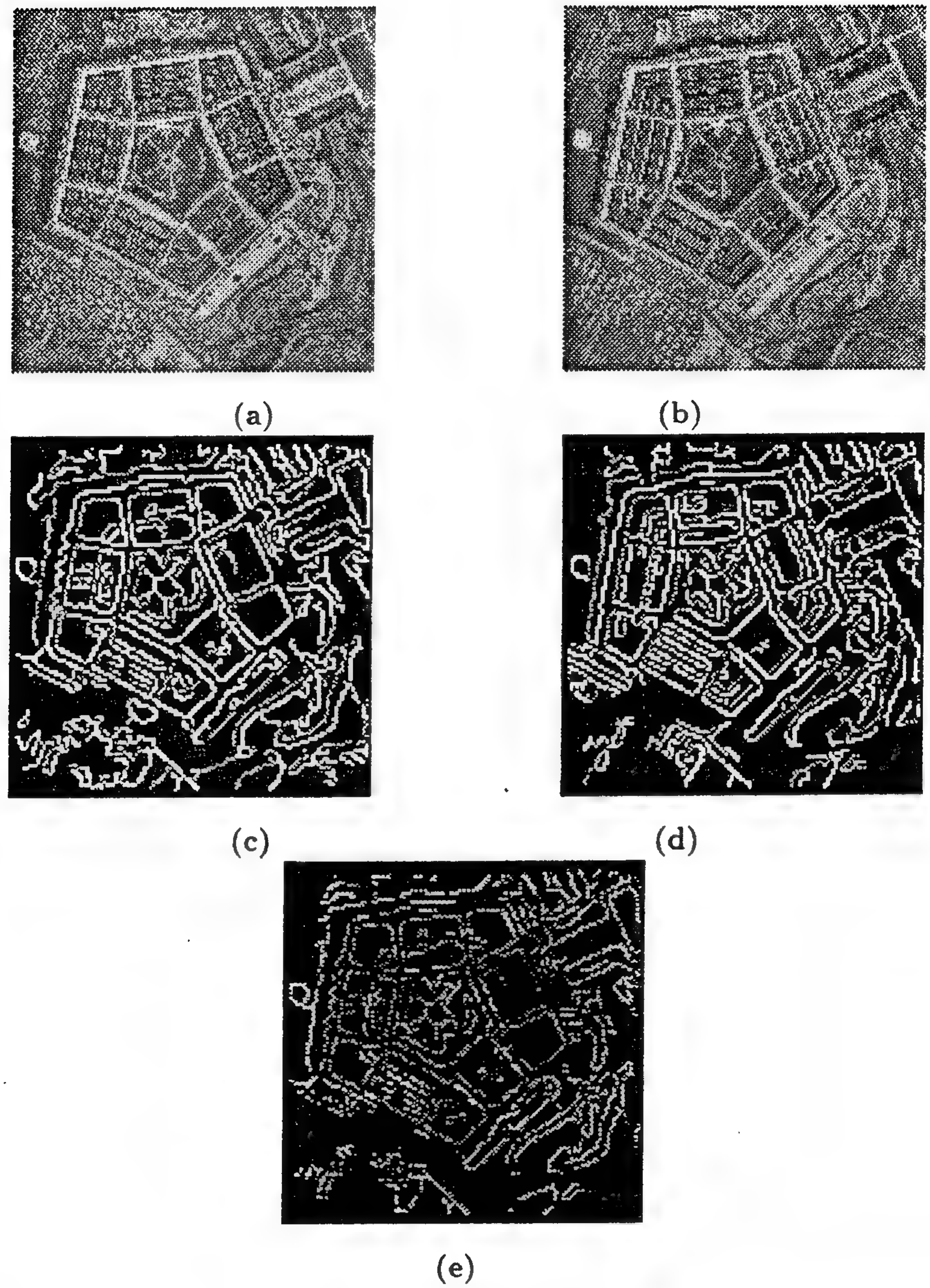


Figure 17: Result for Prazdny's Method for Penatgon pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edge are brighter than negative edges. (e) Disparity Map at edges only. Brighter edges are far from the viewer.

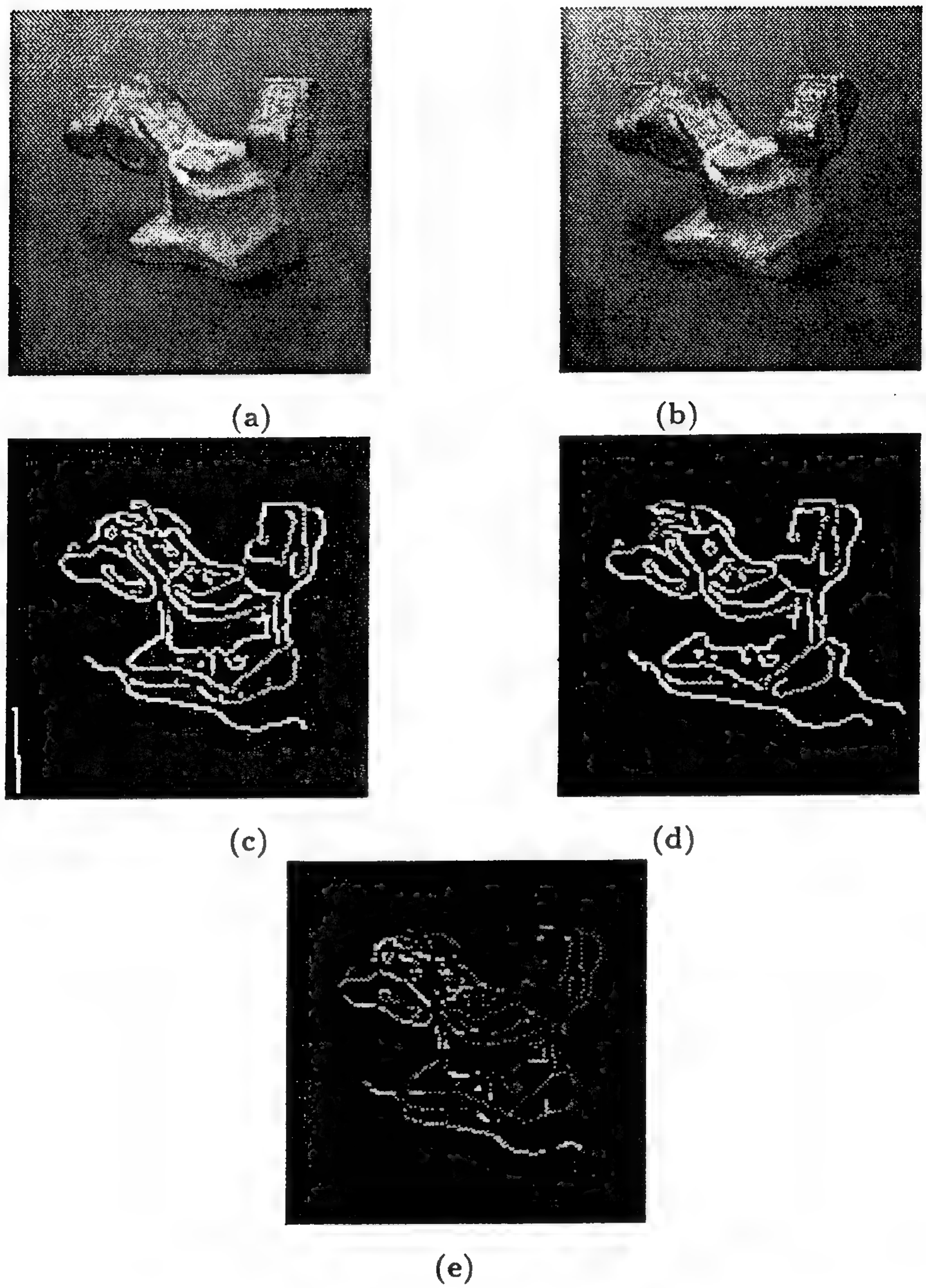


Figure 18: Result for Prazdny's Method for Renault pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edge are brighter than negative edges. (e) Disparity Map at edges only. Brighter edges are far from the viewer.

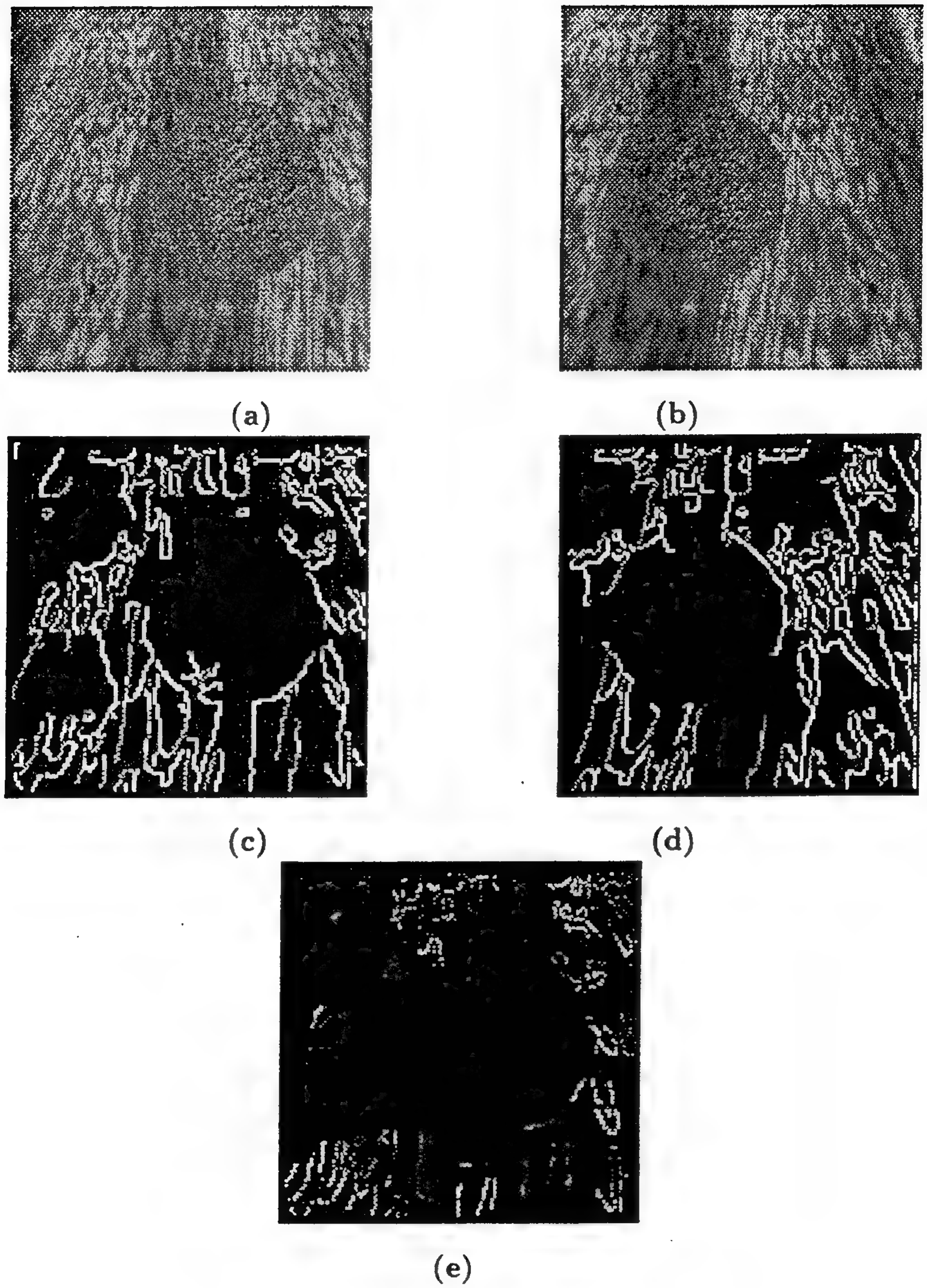


Figure 19: Result for Prazdny's Method for Sphere pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edge are brighter than negative edges. (e) Disparity Map at edges only. Brighter edges are far from the viewer.

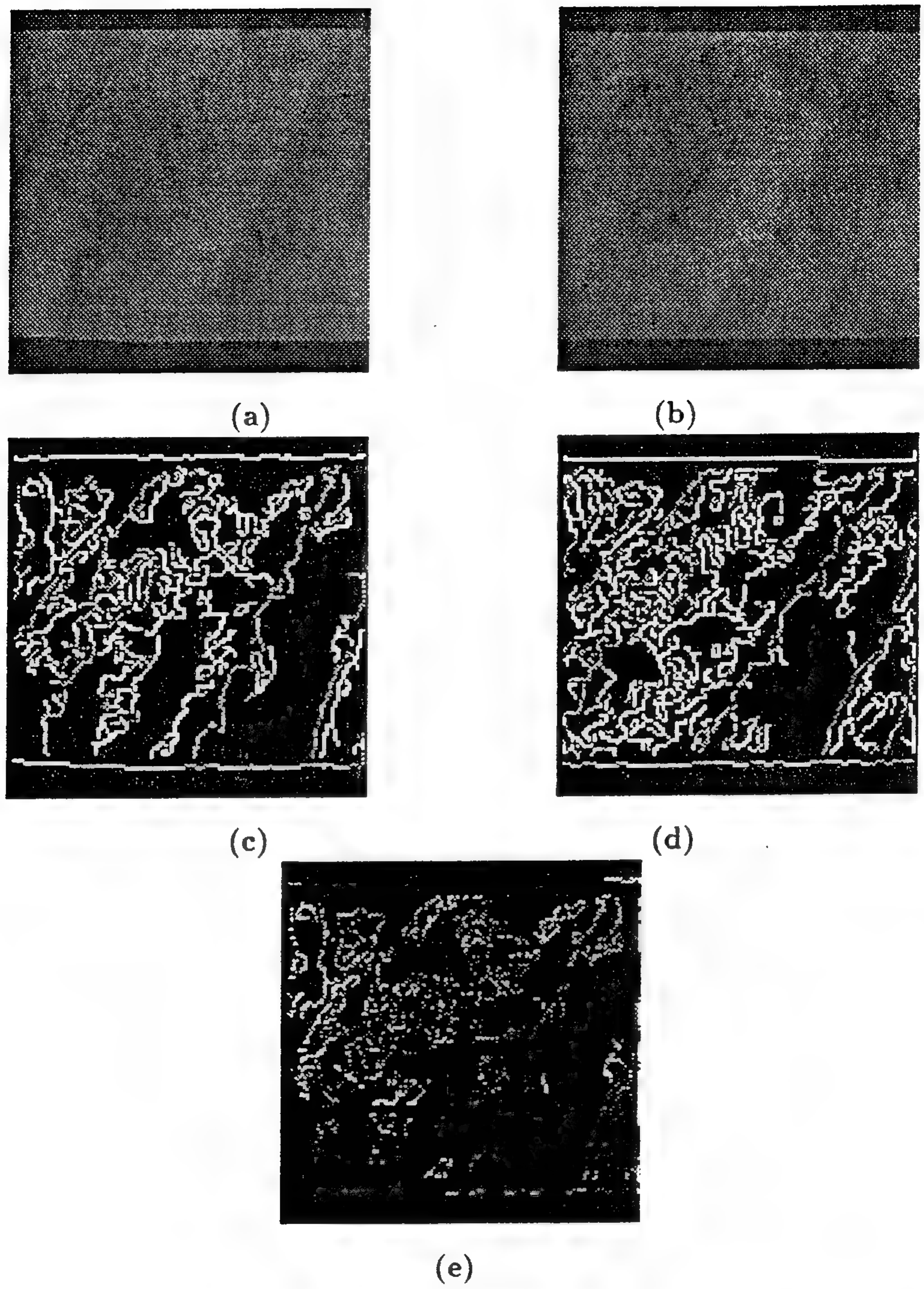
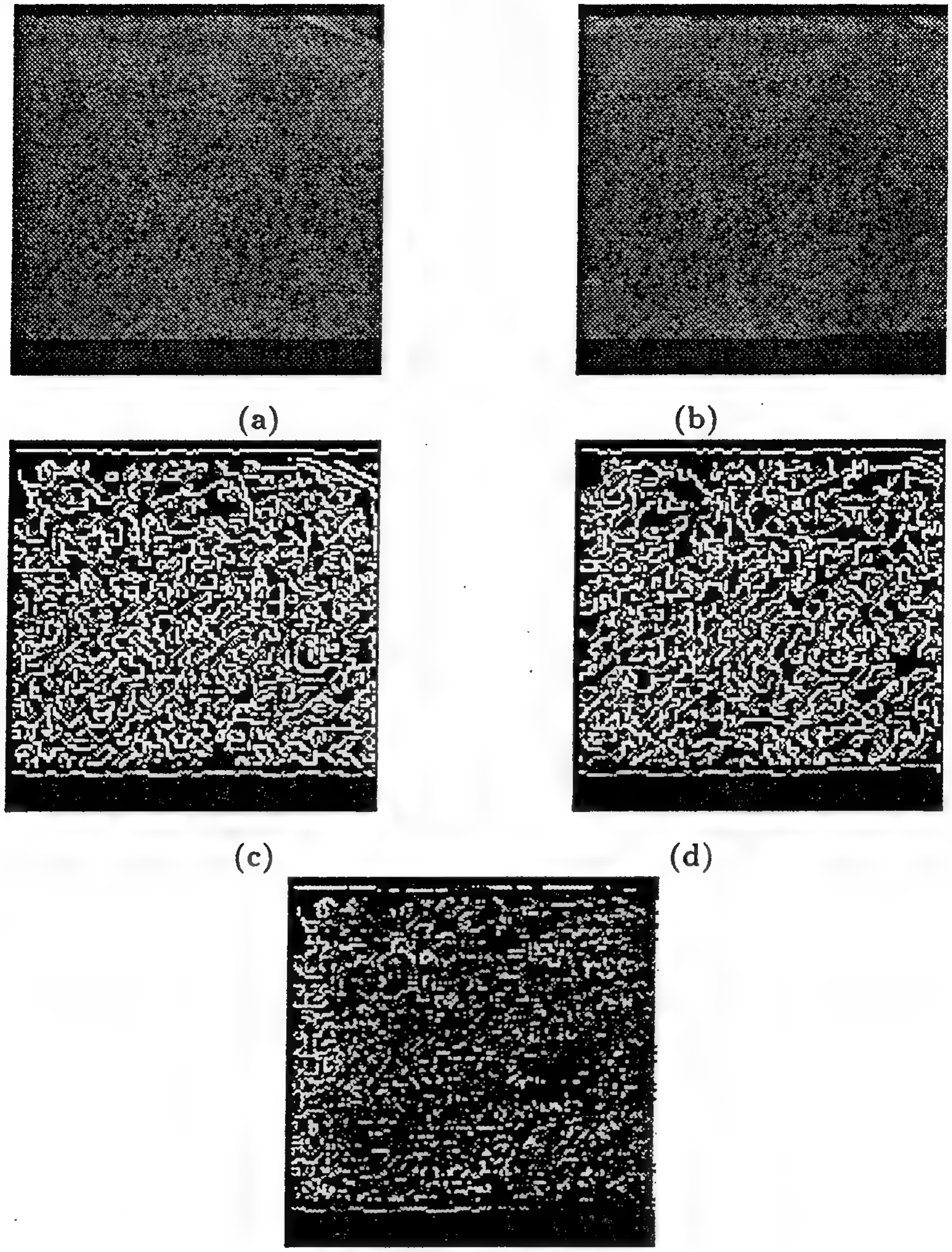


Figure 20: Result for Prazdny's Method for Ruts pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edge are brighter than negative edges. (e) Disparity Map at Edges only. Brighter edges are far from the viewer.



(a) (b) (c) (d) (e)

Figure 21: Result for Prazdny's Method for Rocks pair. (a) Left Image, (b) Right Image, (c) Left Edge Map, (d) Right Edge Map. Positive edge are brighter than negative edges. (e) Disparity Map at Edges only. Brighter edges are far from the viewer.

4 Summary and Conclusions

In this report we have described the implementation of three stereo algorithms. Two algorithms are correlation type, while the third one is edge based. The algorithms were also tested on a set of stereo pairs, and compared in terms of cpu time and the overall results. It was found that difference and normalized correlation methods give almost similar results, except that difference method is order of magnitude faster than the normalized correlation method.

In case of prazdny's method, which is edge based, the disparity values are computed only at edge points. Therefore, in order to obtain disparity values on other points the surface interpolation is necessary. The Difference and Normalized Correlation methods don't perform well for the textured images. However, Prazdny's method still give good result since it computes disparity at edge points only. One of the limitations of all these methods is that the maximum disparity range is to be known beforehand.

The execution time of the algorithms reported is reasonable for image size of 128×128. But, the algorithms will slow down significantly if the original size of images (512×512) is used. However, the execution time can be easily reduced to few seconds by using additional hardware boards e.g. Data Cube convolution boards for the Sun Workstation.

Our future work will focus on improving these algorithms by incorporating the smoothness and continuity criteria. We will also study some other 3D cues like *shading*, and attemp to combine these cues with stereo. It is expected that the performance of such method using multiple cues will be much better than the one using only single cue. We will also start an initial study related to segmentation of 3D surfaces followed by the interpolation step.

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[1] K.Prazdny, *Detection of Binocular Disparity*, *Readings in Computer Vision*, 73-79, 1986.

[2] Steven D. Cochran and Gerard Medioni, *Accurate Surface Description from Binocular Stereo*, IEEE Workshop interpretation of 3-D Scenes, 16-23, 1989.

[3] Ali E. Kayalap, *High Speed Machine Perception Using Passive Sensing Technology*, SPIE Mobile Robots IV vol 1195. 33-43, 1989.

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CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
January 1991

PREPARED BY:

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CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 DEC 1990

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

9/26 K

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$138,637.34	$64,605.00	$74,032.34	$25,213.44	$7,013.80	$18,199.64
TRAVEL	$4,090.54	$854.98	$3,235.56	$2,495.59	$0.00	$2,495.59
OTHER DIRECT COSTS	$6,674.89	$3,390.84	$3,549.69	$265.64	$1.65	$263.99
INDIRECT COSTS	$72,016.09	$33,166.51	$38,021.64	$12,472.39	$3,353.47	$9,118.92
TOTAL EXPENDITURES	$221,418.86	$102,017.33	$118,839.23	$40,447.06	$10,368.92	$30,078.14

Spoke to Emily 9/4
See

2 mo

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 22 NOV						
SMART	231.00	118.00	113.00	34.00	19.00	15.00
KLASKY	1,134.00	606.00	528.00	160.00	0.00	160.00
MORIE	602.00	0.00	602.00	96.00	0.00	96.00
BOWYER	376.00	376.00	0.00	0.00	0.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	751.00	112.00	639.00	80.00	40.00	40.00
MOSHELL	316.00	138.00	178.00	64.00	0.00	64.00
ALTMAN	182.00	128.00	54.00	0.00	0.00	0.00
LISLE	505.00	0.00	505.00	160.00	0.00	160.00
BUCKLEY	761.25	0.00	761.25	113.50	0.00	113.50
STARK	900.00	900.00	0.00	60.00	60.00	0.00
SAMKOWIAK	18.00	9.00	9.00	6.00	3.00	3.00
JINXIONG	80.00	0.00	80.00	0.00	0.00	0.00
BLAU	480.00	480.00	0.00	160.00	160.00	0.00
MANGUM	232.25	0.00	232.25	23.25	0.00	23.25
WATKINS	216.50	66.00	150.50	0.00	0.00	0.00
CAMPBELL	318.00	318.00	0.00	80.00	80.00	0.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
BRYDEN	113.25	0.00	113.25	113.25	0.00	113.25
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	7396.25	3334.00	4062.25	1150.00	362.00	788.00

Monthly Report January 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. **Sponsor Demonstration** - On January 25, VSL held a demonstration of all PM-TRADE funded projects. Included in this was the first exhibit of the software which was created under the Geospecific Database Project. The two major components of the software were shown. Dr. Shah's computer vision analysis of stereo images and Dr. Boyer's vision analysis of shadows. The first set of programs demonstrated the data path from stereo images (using three different stereo techniques) to CAD database to flight. The second set of programs shows shadow analysis straight to flight.

2. **General Electric** - On January 31, part of the VSL went to General Electric to start a basic working communication and propose some combined work. The main intent of going to GE in terms of this project was looking specifically at the TARGET database product. The people at GE gave us a very informative demonstration of this software package. This database tool is important because it has the same family of problems associated with the Geospecific project. Hopefully more information about this product will be coming.

3. **First Year Objectives** - January was the end of the first year of this project. During this month was mostly cleanup of the software and documentation. There have been some added features to Lisle's ANIM program which give a better view of the database. Also, all of the documentation has been completed. We have received a summary report from Dr. Shah of the work that he has been doing. This report is attached.

Problems

One of the goals previously set was to get all of the various programs working on the Silicon Graphics workstation running under Xwindows. This has been accomplished for most of the programs. There still are some logistical problems which will take some time to work out. These are not problems which are in the way of doing work. All programs work correctly as they stand now, but the transition to Xwindows will take some time.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
February 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 JAN 1991

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$156,234.40	$67,024.56	$89,209.84	$17,597.06	$2,419.56	$15,177.50
TRAVEL	$4,090.54	$854.98	$3,235.56	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$10,539.42	$4,521.41	$6,018.01	$3,598.89	$1,130.57	$2,468.32
INDIRECT COSTS	$80,565.43	$34,134.83	$46,430.60	$9,377.28	$968.32	$8,408.96
TOTAL EXPENDITURES	$251,429.79	$106,535.78	$144,894.01	$30,573.23	$4,518.45	$26,054.78

	CUMULATIVE HOURS	TASK 1 CUMULATIVE HOURS	TASK 2 CUMULATIVE HOURS	CURRENT HOURS	TASK 1 CURRENT HOURS	TASK 2 CURRENT HOURS
LABOR HOURS THROUGH 17 JAN 91						
SMART	255.00	130.00	125.00	24.00	12.00	12.00
KLASKY	1,294.00	606.00	688.00	160.00	0.00	160.00
MORIE	742.00	0.00	742.00	140.00	0.00	140.00
BOWYER	376.00	376.00	0.00	0.00	0.00	0.00
PROVOST	16.00	16.00	0.00	0.00	0.00	0.00
NELSON	751.00	112.00	639.00	0.00	0.00	0.00
MOSHELL	340.00	138.00	202.00	24.00	0.00	24.00
ALTMAN	182.00	128.00	54.00	0.00	0.00	0.00
LISLE	665.00	0.00	665.00	160.00	0.00	160.00
BUCKLEY	813.50	0.00	813.50	52.25	0.00	52.25
STARK	900.00	900.00	0.00	0.00	0.00	0.00
SAMKOWIAK	18.00	9.00	9.00	0.00	0.00	0.00
JINXIONG	80.00	0.00	80.00	0.00	0.00	0.00
BLAU	616.00	480.00	136.00	136.00	0.00	136.00
MANGUM	284.25	0.00	284.25	52.00	0.00	52.00
MULLALLY	44.50	22.25	22.25	44.50	22.25	22.25
WATKINS	216.50	66.00	150.50	0.00	0.00	0.00
CAMPBELL	398.00	398.00	0.00	80.00	80.00	0.00
ROY	67.00	67.00	0.00	0.00	0.00	0.00
BRYDEN	273.25	0.00	273.25	160.00	0.00	160.00
LI	97.00	0.00	97.00	0.00	0.00	0.00
TOTAL LABOR HOURS	8429.00	3448.25	4980.75	1032.75	114.25	918.50

Monthly Report February 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. Conducted meetings with Dr. Shah about plans for the second year of work on the project. Shah's work is summarized as follows :

- Continue implementations of stereo algorithms
- Perform experiments with different types of stereo images, specifically those involving buildings
- Comparative study of different stereo techniques
- Improve depth maps by introducing constraints on the stereo algorithms, for example, applying edge based constraints
- Fit planar and quadratic surfaces to the models derived from the stereo images

2. Plans for a meeting with Dr. Boyer have been delayed until the first week in March, due to travel by Boyer. Plans for discussion are about the shadow work to be done in the next year. Boyers plans for this year will be included in next months report.

3. Blau has conducted some limited experiments on different types of stereo images. This is to help Shah and his student better define the constraints which must be added to their programs.

Problems

There are no problems at this time.

Monthly Report: February 91

Project: Multiple Image Generator Databases (MIDB)

Project Lead: Curtis Lisle

Accomplishments: Several separate efforts are underway within the MIDB project. Major developments for each area are listed separately.

1. SIMNET Databases: Lisle and Morie have constructed, loaded, and viewed an articulated, multi-LOD model of a HMMWV vehicle on IST's SIMNET. This vehicle served as a test case for the development of dynamic, 3-dimensional models in the SIMNET environment. We can compile DED (dynamic element databases) composed of 3D models into a run-time format and view them on the SIMNET system. This was a necessary milestone in IST's understanding of the SIMNET system in order to develop databases for it.

2. MultiGen to ESIG Interface: In our last report, IST described the arrival of software from Software Systems which would be included in the ESIG formatter. Upon our first review, the algorithm, which can add static priority to any arbitrary database, will be hard to integrate into IST's formatter.

3. Project 2851: IST is considering how to become a test site for P2851 GTDB data. We are in negotiations with PRC, MacLean, VA. over this issue currently.

Problems: The static priority database requirement for the ESIG-500 may make automated database generation for it difficult. Investigation is underway here.

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

February 28, 1991

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Greene AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Greene:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the February 1991 time period are forwarded for your review and/or approval.

If you have any questions, please call me at 658-5000.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (A001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
March 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 28 FEB 1991

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES
FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$175,902.63	$69,657.44	$106,245.19	$19,668.23	$2,632.88	$17,035.35
TRAVEL	$6,409.31	$2,509.27	$3,900.04	$664.48	$0.00	$664.48
OTHER DIRECT COSTS	$11,194.20	$5,597.11	$5,597.09	$654.78	$1,075.70	($420.92)
INDIRECT COSTS	$91,479.37	$36,725.80	$54,753.57	$10,913.94	$2,590.97	$8,322.97
TOTAL EXPENDITURES	$284,985.51	$114,489.62	$170,495.89	$31,901.43	$6,299.55	$25,601.88

	CUMULATIVE HOURS	TASK 1	TASK 2
HOURS REPORTED			
PREVIOUS REPORT	8,429.00	3,448.25	4,980.75
CURRENT HOURS			
MOSHELL	24.00	0.00	24.00
SMART	42.00	20.00	22.00
KLASKY	188.00	0.00	188.00
LISLE	240.00	0.00	240.00
MORIE	160.00	0.00	160.00
CLARKE	8.00	0.00	8.00
SAMKOWIAK	4.00	2.00	2.00
NELSON	92.00	0.00	92.00
BUCKLEY	111.00	0.00	111.00
CAMPBELL	120.00	0.00	120.00
GOEL	180.50	0.00	180.50
STARK	180.00	180.00	0.00
BLAU	176.50	176.50	0.00
MULLALLY	108.50	0.00	108.50
M SMITH	61.50	0.00	61.50
REHFELDT	5.75	0.00	5.75
TOTAL CURRENT HOURS	1701.75	378.50	1323.25
CUMULATIVE HOURS	10130.75	3826.75	6304.00

Monthly Report March 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. Conducted meetings with Dr. Boyer during the first week of march about plans for the second year of work on the project. Their work is summarized as follows :

- One of the efforts will be to get all of Boyers software working on the same computer platform as Shah software. There was an effort during the last part of the first year to accomplish this task, but there were some problems with operating system software. Solutions to these problems should be working within the next 2-3 months.

- Boyers height by shadow extraction software is going to be enhanced in a number of ways. A better user interface is going to be added and the height extraction algorithms are going to be improved. Automatic detection of buildings by edge finding will help the user decide which parts of the image contain buildings. Along with the improvements in the human interface, the users of this software should be able to better build databases from images.

2. Plans are to attend the SPIE AeroSpace Sensing '91 Photonics Exhibition. We are able to attend at no cost because the university is a partner in the production of the exhibition. Image processing, scanning and satellite imagery will be some of the features that we will look at.

Problems

There are no problems at this time.

Monthly Report: March 1991

Project: Multiple Image Generator Databases (MIDB)

Project Lead: Curtis Lisle

Accomplishments: Several separate efforts are underway within the MIDB project. Major developments for each area are listed separately.

1. SIMNET Databases: A complete DED (dynamic element database) containing all the standard SIMNET models (m1, ah64, m2, etc.) along with IST-developed models for an NLOS HUMMWV and FOG/M missile was built and sent to Ft. Rucker for testing on the NLOS project. The NLOS trainer is networked to existing SIMNETs at Rucker. This will provide proof of IST's capability to generate workable polygon models of vehicles and munitions in support of an existing SIMNET site.

More progress has been made understanding the SIMNET database development process using S1000. We are beginning to study the S1000 datafile formats for integration of these tools into IST's SimData Center toolset (a complete database development environment).

2. IST/Army ETL Meeting: Jacki Morie met with Kevin Muhm, Rick Herrmann of ETL and Ray Green of PM-TRADE. We discussed future cooperation between ETL and IST for visual database technology. Specifically, ETL agreed to provide the finished Ft. Hood database along with ITD, DTED, and imagery to IST. These datasets will be used as input for IST's SimData Center toolset. Cooperation between IST and ETL on Project 2851 issues was also discussed. When completed, ETL will provide their P2851 GTDB-to-Boeing formatter to IST.

2. MultiGen to ESIG Interface: In the February 91 report, polygon priority for the ESIG database was identified as a problem we encountered. We have made progress in solving this using the programs from Software Systems (for reference, see February 91 report). The results look very good: We have correctly "prioritized" most of the Research Park database previously demonstrated to PM-TRADE. Correct priority order from any viewpoint is provided by identifying *separating planes* which allow the IG to display features in the correct visual order. Previous

to this month, IST had no way of generating separating planes from a MultiGen database.

3. Project 2851: IST has responded to the Statement of Work sent by PRC, McLean, VA requesting sights to convert P2851 GTDBs for display on various IGs (image generators). In our discussions with PRC, we believe UCF/IST has a good chance to be funded by P2851 to convert a GTDB for display on our SIMNET and ESIG-500 IGs. IST will be an evaluation site for P2851 GTDBs even if we are not chosen to convert a database. The amount of cooperation between PRC, the P2851 contractor, and IST is increasing.

Problems:

• IST has no support contract with BBN for the S1000 tools. We, therefore, do not receive any software updates. As of this writing, our versions of S1000 are already somewhat out-of-date. If this problem remains, IST will not be compatible with other S1000 sites (such as Army ETL).

• Testing of articulated, dynamic models is not possible using a single IST SIMNET since we are at version 6.0 of the real-time software on the CIG. We can work around this for now, but this brings up the same upgrade question. IST should be kept current, or have the means to acquire upgrades as needed to keep our work relevant to the services and industry.

[illegible] Ernie - get + upgrades

Spoke to Ernie 4/4/91
[illegible] to PRT [illegible] -
It will [illegible] S1000 update [illegible]
SIMNET update to 6.6 via
contract - [illegible] & on ADST etc
KB.

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

March 29, 1991

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Greene AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL A001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Greene:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the March 1991 time period are forwarded for your review and/or approval.

If you have any questions, please call me at 658-5000.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
April 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 APRIL 1991

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES
FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$209,608.79	$76,539.18	$133,069.61	$12,650.33	$3,861.51	$8,788.82
TRAVEL	$6,935.51	$2,509.27	$4,426.24	$526.20	$0.00	$526.20
OTHER DIRECT COSTS	$17,802.11	$8,901.06	$8,901.05	$471.74	$235.87	$235.87
INDIRECT COSTS	$108,553.82	$40,350.49	$68,203.33	$6,551.16	$1,246.81	$5,304.35
TOTAL EXPENDITURES	$342,900.23	$128,300.00	$214,600.23	$20,199.43	$5,344.19	$14,855.24

	CUMULATIVE HOURS	TASK 1	TASK 2
HOURS REPORTED			
PREVIOUS REPORT	10,130.75	3,826.75	6,304.00
CURRENT HOURS			
MOSHELL	0.00	0.00	0.00
SMART	26.00	13.00	13.00
KLASKY	136.00	0.00	136.00
LISLE	160.00	0.00	160.00
MORIE	120.00	0.00	120.00
CLARKE	0.00	0.00	0.00
SAMKOWIAK	2.00	1.00	1.00
NELSON	80.00	0.00	80.00
BUCKLEY	92.00	0.00	92.00
CAMPBELL	116.00	0.00	116.00
GOEL	120.00	0.00	120.00
STARK	120.00	120.00	0.00
BLAU	160.00	0.00	160.00
MULLALLY	74.50	37.00	37.50
M SMITH	39.50	0.00	39.50
CARRINGTON	87.50	0.00	87.50
REHFELDT	8.25	0.00	8.25
TOTAL CURRENT HOURS	1341.75	171.00	1170.75
CUMULATIVE HOURS	11472.50	3997.75	7474.75

Monthly Report May 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. Completed the in house paper entitled "Automatic Database Generation". This paper asks some general questions of the research group (Dr. Mubarak Shah (UCF), Dr. Kevin Boyer (USF), Dr. Michael Moshell (IST), Curt Lisle (IST) and Brian Blau (IST)) about how computer vision and database construction relates. The ideas of realtime image processing and realtime computer vision are going to be important in the future of IG database issues. The report is intended to serve as a starting place for future projects for this group. The report entitled "Automatic Database Generation" is included with this monthly report.

2. The meeting with Dr. Shah did not take place as planned because of scheduling conflicts. Another meeting with both Dr. Shah and Dr. Boyer will be scheduled soon.

3. Curtis Lisle attended the Project 2851 Rapidly Reconfigurable DataBase design review May 1-3. Issues discussed included feature extraction and geopositioning from Multi-Spectral Imagery. IST has received the report from PRC entitled "Multi-Source Imagery Investigation" and will be reviewing it.

Problems

There are no problems at this time.

Automatic Database Generation

VSL Document 90.14
Date written : 5/3/91
Date printed : 6/3/91

Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training
Orlando Florida

[**Note** : I would like this document to serve as a prelude to a meeting during the first week of July. The entire group (Dr. Mubarak Shah (UCF), Dr. Kevin Boyer (USF), Dr. Michael Moshell (IST), Curt Lisle (IST) and Brian Blau (IST)) should meet at this time. I will make arrangements and coordinate the scheduling. Please review this document, as it will be the basis for some of the discussion at the meeting. Additionally, I would like this paper to be a start for discussion about future projects. This report is included with the May Monthly report to PMTRADE.]

1.0 Introduction

During the last year, the Visual Systems Laboratory has been involved in the Rapidly Reconfigurable DataBase project which is funded by the Army's PMTRADE. There are two main tasks which IST has undertaken. The Geospecific Data Center will function as an operational showcase of the technology which is used in the rapid production and integration of databases. The raw sources will be digital geographic data, photographs, stereo pairs, maps, charts and already existing database. The other task involves the production of a standard simulator database.

It has become clear that there are many areas of this project that the VSL will not be able to investigate or possibly learn given our background. This is why, from time to time, papers like these will be presented to the sub tasks for their comments and suggestions.

In this paper, the idea of building databases from realtime image processing will be discussed. During the last few years, the IP market has produced very impressive realtime products that are used in a variety of applications. Not only has the commercial market seen this advancement, but it was evident that in the Gulf War, there were many uses of "smart weapons" that could find their way to targets and destroy them.

The main question is; can we use realtime image processing to build image generator databases, either totally automatically, or with human help? Additionally, how will this database correlate with already existing databases? This question is broken down into two parts, one for the vision group and one for the image generator database group. First, is it feasible to use realtime image processing in the context of building databases? Second,

is there useful information from image processing that can be applied to database construction?

2.0 Image Processing Capabilities

There are several questions that are raised when talking about realtime image processing. First, how fast is realtime and what are the operations that can be performed in a given time slice. In traditional image generator technology, realtime can be as slow as 1-3 Hz and as fast as 50-60Hz. The system guarantees that each frame will last no longer that the given amount of time, and the image will be displayed at the end of each clock tick. The main question is, how fast is fast?

Another area of concern is the capabilities of the realtime image processing system. During a recent SPIE conference exhibition [SPIE 91], there were systems demonstrated that could detect edges and motion detect at 15-30Hz (like DataCube, Intergraph(?), Recognition Concepts TrapixPlus). Does this represent the state-of-the-art in realtime image processing?

Additionally, can these systems be extended?. For example, can users add routines and functions to the system which would be executing under realtime control. Maybe there are applications which need additional functionality which is beyond the basic IP system. Can these functions be incorporated, and can these additions cause the IP system to degrade to non-realtime performance.

An additional question about an image processing system. How closely are the image system (cameras) and the image processors tied? Are they separate functional modules which can be interconnected to various other IP components, such as disks and CPU's? Or are these systems mainly closed with little or no hope of outside integration?

3.0 Scene Analysis

In the fields of computer vision and image processing, scene analysis is incorporated into many different projects. This term can imply complete analysis of a particular aspect of the scene, or it maybe the analysis of motion. In either case, how much practical information can be obtained from a realtime IP system? Data such as edges, objects, humans faces (from Pentlands symposium at UCF) and buildings are of interest.

4.0 Building a Database

The main reason we at VSL are interested in IP systems still remains around building image generator databases. Part of the current project is to investigate technological areas in both research and industry which have developed these capabilities.

Computer vision group : How can a database be built from a computer vision or image processing system? Database group : Is there data that can be obtained via IP/CV algorithms which can be directly added to an IG database? There are many different flavors of IG and their input databases.

Most of the popular IG systems which are available to industry and military have specialized software front ends which manage their databases. Currently, there is an industry wide effort to build formatters which can take raw data and convert it to any IG database. There are additional efforts to establish standard database formats which will be used by the entire industry. These standard database will be used in the exchange of data, protecting the internal formats of the specific vendors, but supplying databases which can be sent between vendors. This capability is needed for military use.

These specialized database tools can accept many different forms of data. There are some that even perform complex tasks such as data correlation, where raw sources must be processed to match other sources. I would like to know if there are places where information from IP systems can be brought into these database tools.

5.0 Additional Projects

The following section is a proposal for ideas and projects that will fit under the current RRDB task. These are not meant as specific goals, but as a framework for discussion.

5.1 Stereo Images

One of the possible alternatives for stereo images are from synthetic sources. Although this may not be the best option for obtaining images, it certainly is attractive because many images of varying quality can be generated quickly. What are the advantages and disadvantages in using synthetic images versus real images for the development of algorithms for stereo analysis?

This is a problem that we (VSL and UCF) have had in the past. Obtaining stereo images of buildings which have corresponding ground truth is not an easy task. During the discussions on the net's comp.vision on this particular subject, no one seemed to have any answers on if these image are available. I propose that VSL make these pictures for Shah. This can be done using one of the advanced modeling packages what are now located at VSL. These scenes are very realistic and can be generated in a short time. There may be ways to incorporate textures from real images in these synthetic images. Additionally, these modeling packages can add fog, haze, clouds and many other features to make the pictures as realistic as possible.

Can we use images such as these generated by modeling packages? Is this an alternative to getting actual pictures of buildings? How much data would be lost from the scene analysis when using these computer generated images?

Another possible source for stereo images is our friends in Daytona Beach, FL at GE. They have advanced image generators and modeling tools. They

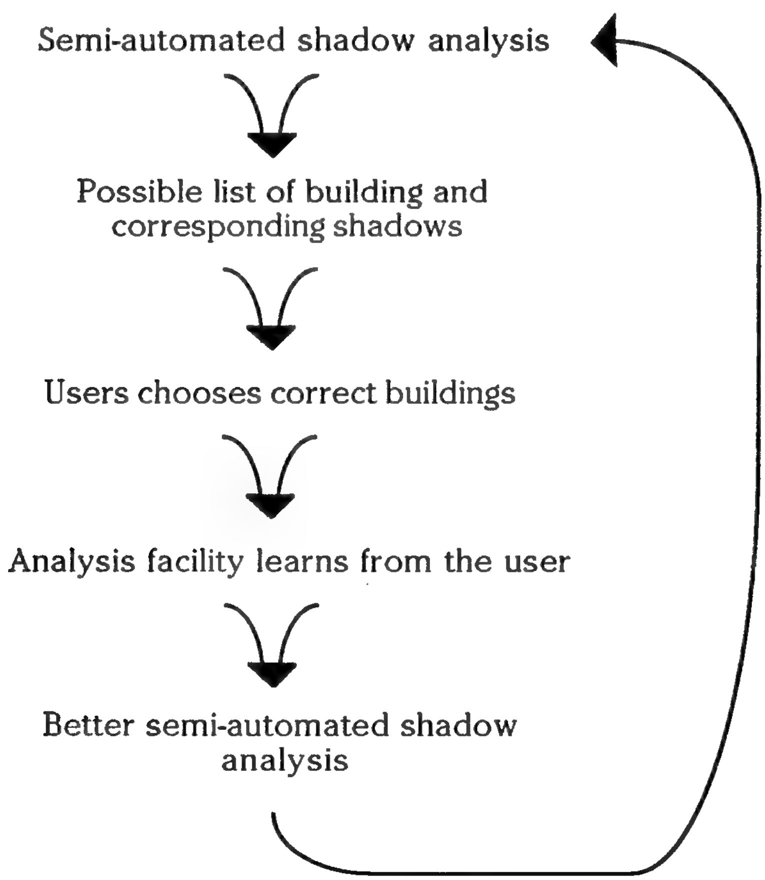
should have already, or could generate easily, stereo pairs. Is this worth investigating?

4.2 Semi-Automated Database Construction

Alternative database construction tools in the simulation industry are needed. To facilitate the rapid production goals of the military and civilian governments, database tools need to automatically read raw sources and produce raw databases which can then be refined.

The following is a possible solution for this problem. This algorithm takes raw data, and after learning about the data from some user, constructs a database. This knowledge obtained from the user can be used as a starting place for building additional databases.

The example shown uses shadow analysis as the base processing tool. Each image is examined and a possible list of buildings is generated. The user selects the correct buildings and the processing system learns. The process is repeated, and as more databases are built, the automatic extraction of buildings will increase in accuracy.



Are these types of algorithms currently available, such as in neural networks? I think it would be interesting and useful to start looking at some of this kind of technology for possible future project ideas.

In addition, there are new technologies being developed which are similar to image generator database construction. There is a group at Ohio State Center for Mapping [Novak 91] which has developed an entire stereo mapping system. They have constructed a stereo system mounted atop a van. The image processing system detects the road, and along with a global positioning system, creates a map. These new developments, along with others need to be investigated.

5.0 Conclusion

There are many questions that are raised in this paper. Many are basic to the understanding to stereo imaging and processing and others are questions about broad areas of database construction. To better support the efforts of IST/VSL, these questions need attention. VSL will continue to investigate and report their findings on these topics. All the members of the GeoSpecific research team are encouraged to do so as well.

References

[SPIE 91] SPIE AeroSpace Sensing 91 Photonics Exhibition, Marriott World, Orlando, FL., April 1991.

[Novak 91] Novak, K., Johnson, P. C., Orvets, G., "Stereo Imaging Meets GIS for a Highway Database," Advanced Imaging, vol. 6, no. 4., pp 38-41, 100, April 1991.

Monthly Report: May 1991

Project: Multiple Image Generator Databases (MIDB)

Project Lead: Curtis Lisle

Accomplishments: Several separate efforts are underway within the MIDB project. Highlights of the past month are listed below by category.

1. SIMNET Databases: Several tools were added to the SimData Center toolset this month. They are described briefly here:

S1000 Viewing Tool - The S1000 model viewing tool has been improved since its announcement in last month's report. It provides quick a quick, interactive preview for non-articulated models on Iris workstations.
Model Import to S1000 Tool - This tool takes polygonal databases in a neutral format and converts it to S1000 format. The IST database developed in MultiGen has been converted to S1000 format. We hope to have this database visible on the SIMNET CIGs soon.
S1000 Polygon Stretch Tool - A tool was written which "stretches" polygons, causing a small amount of overlap between adjacent polygons in polygonal models. This is necessary to overcome shortcomings in the SIMNET CIG architecture.
ITD-GRASS Formatter - Ron Klasky has written converter programs which import ITD data into the GRASS Geographic Information System vector format. The Ft. Hood ITD data has been converted.

2. Project 2851: Curt Lisle attended the Preliminary Design Review for the RRDB extension of Project 2851 on May 1-3, 1991. Curt briefed Ray Green on the meeting May 14, 1991 at PM-TRADE. The meeting covered Multi-Spectral Imagery and the changes to the SSDB and GTDB designs to include photo-texture. IST has received word from PRC (the P2851 contractor) that it has been chosen to convert and review a P2851 GTDB during P2851's FSD/OT phase.

3. MultiGen to ESIG: Improvements were made to the ESIG-500 formatter program. It is now complete enough to exercise with several test databases over the coming months.

4. Ft. Hood Database: IST has just received Landsat, NHAP (National High Altitude Photography), and DTED level 1 data for the same area. This will be used as input data for a Ft. Hood database IST will develop.

Problems:

none at this time

UNIVERSITY OF CENTRAL FLORIDA
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12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

May 31, 1991

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progrss, Status and Management Reports and Cost Reports for Task 1 and 2 for the April 1991 time period are forwarded for your review and/or approval.

If you have questions, please contact me at 658-5000.

Sincerely,

Ernie Smart,
Program Manager

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports
May 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 MAY 1991

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$237,493.79	$80,035.40	$157,458.39	$27,885.00	$3,496.22	$24,388.78
TRAVEL	$9,755.51	$3,797.20	$5,958.31	$2,820.00	$1,287.93	$1,532.07
OTHER DIRECT COSTS	$61,443.43	$30,721.72	$30,721.71	$43,641.32	$21,820.66	$21,820.66
INDIRECT COSTS	$122,540.53	$42,329.63	$80,210.90	$13,986.71	$1,979.14	$12,007.57
TOTAL EXPENDITURES	$431,233.26	$156,883.95	$274,349.31	$88,333.03	$28,583.95	$59,749.08

	CUMULATIVE HOURS	TASK 1	TASK 2
HOURS REPORTED PREVIOUS REPORT	11,472.50	3,997.75	7,474.75
CURRENT HOURS			
MOSHELL	8.00	0.00	8.00
SMART	14.00	7.00	7.00
KLASKY	70.00	0.00	70.00
LISLE	160.00	0.00	160.00
MORIE	120.00	0.00	120.00
CLARKE	0.00	0.00	0.00
SAMKOWIAK	0.00	0.00	0.00
NELSON	65.00	0.00	65.00
BUCKLEY	74.00	0.00	74.00
CAMPBELL	60.00	0.00	60.00
GOEL	120.00	0.00	120.00
STARK	80.00	80.00	0.00
BLAU	160.00	160.00	0.00
MULLALLY	106.50	71.50	35.00
M SMITH	27.00	0.00	27.00
CARRINGTON	60.00	0.00	60.00
OTTE	11.00	0.00	11.00
REHFELDT	0.00	0.00	0.00
TOTAL CURRENT HOURS	1135.50	318.50	817.00
CUMULATIVE HOURS	12608.00	4316.25	8291.75

Interim Status Report for the Multiple Image Generator Database Project

Curtis Lisle
IST Visual Systems Lab (VSL)
April 15, 1991

Project: BAA #0042 - Task #2: Production of Standard Simulator Databases for Multiple Image Generators.

Purpose: This document summarizes the work which has been accomplished during the first year of this two year contract and outlines the areas where work will continue during the second year of the project.

Goal of MIDB Project: The MIDB (Multiple Image Generator Database) project endeavors to establish a standard method of constructing run-time databases for multiple low-cost image generators from a single set of input source data. To support this goal, a suite of software tools (referred to collectively as the SimData Center) for database construction is being created by IST.

Format of this Document: This document describes the architecture of the SimData Center and lists the project's first year accomplishments in each of several major areas.

SimData Center Software

The SimData Center, when complete, will be able to transfer input source data into run-time databases for image generators (IGs) from different vendors. The basic dataflow of the center is shown in Figure 1.

Input Process: Several standard data input formats will be supported, including DMA DTED, DFAD, and Project 2851 GTDB. Each different source format will be converted by a Formatter Program (FP) and converted into a *Flight* format database (a public-domain polygonal data format created by Software Systems).

Software System's MultiGen package will be used to correlate, register, and combine the data from each input format once it has been converted to *Flight* since MultiGen is a complete development environment which operates on the *Flight* format.

Compiling for Run-Time: Once a completed database exists in *Flight* format, it will be compiled by separate sets of software to produce run-time databases for different IGs. Figure 1 shows the first two paths planned which support the BBN Delta Graphics SIMNET IG and the Evans & Sutherland ESIG-500 IG.

In each case, the compilation is performed by writing a formatter program which converts a database from *Flight* format to a format suitable for input into the

vendor-supplied tools. Vendor-supplied tools are used because the run-time format for each IG is usually proprietary and is optimized for performance of that particular system. It is more efficient for IST/VSL to avoid the machine-dependent run-time formats.

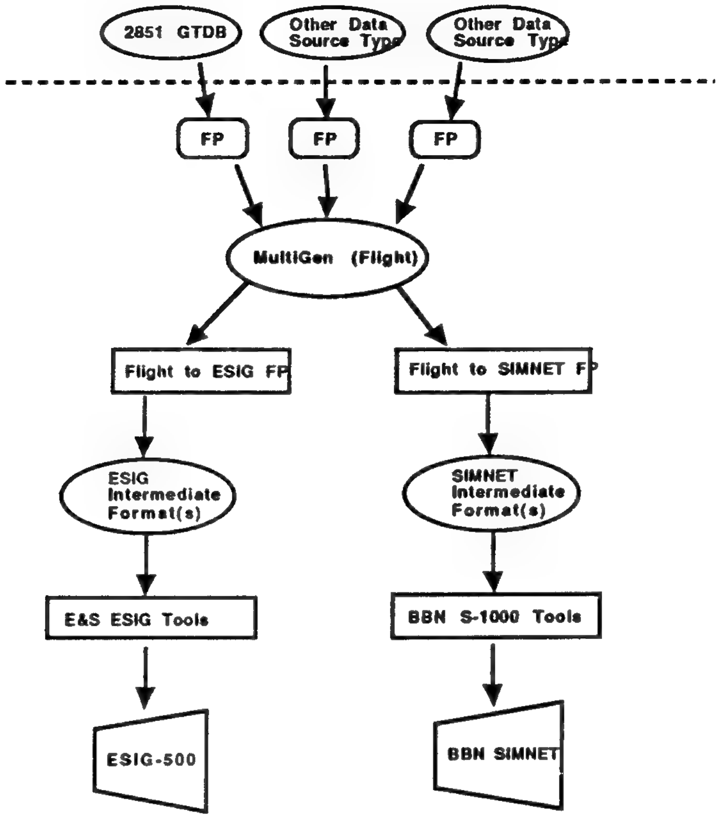

Figure 1 - SimData Center Dataflow

Toolset List: The following list shows some of the tools planned for inclusion in the SimData Center at the end of the second year of the project:

- **MultiGen to ESIG Formatter:** Take a *Flight* format database and convert it for input into the E&S compiler.

- **MultiGen to S1000 Formatter:** Take a *Flight* format database and convert it for input into the BBN S1000 compiler.

- **S1000 Model Display:** Display a polygonal model in S1000 format on the IRIS workstation. This is a productivity enhancement since models are currently viewable only on the SIMNET CIG.

- **Model Import:** Take polygonal models in a variety of formats and convert them into *Flight* for use in visual databases.

• **ITD Import:** ITD data will be read, converted to *Flight* , and used to provide culture and network features in visual databases.

Accomplishments

Progress has been made during the first year on all parts of the dataflow in Figure 1. The progress is summarized into several categories below:

SIMNET Databases: VSL has acquired and installed the S1000 tools for SIMNET database creation. At the time of this writing, VSL and Army ETL are the only labs outside of BBN with SIMNET database creation capability. Curt Lisle and Jacki Morie were trained on the S1000 tools by a BBN modeler in residence at Army ETL.

We familiarized ourselves with the S1000 environment by creating a demonstration database using the Indian Springs, NV DMA DTED and placing cultural features by hand. After creating this *assembly* (BBN's term for a complete but uncompiled database), we successfully compiled it and transferred the database to the SIMNET CIGs. The compiled database was viewed with the stealth simulator for visual verification. Terrain following and collision detection were verified by driving on the database with the M1 simulator.

After being satisfied that we understood the correct process for static terrain creation, a multiple level of detail, articulated vehicle was created, placed on the SIMNET and tested. This new icon of the NLOS HMMWV vehicle is in use by PRC at the Ft. Rucker SIMNET site. This process involved more learning of the SIMNET architecture than was anticipated.

Evans & Sutherland Databases: We have nearly completed the formatter between *Flight* format and the ESIG tools. This formatter has been tested by using it to convert several polygonal models and a database of the Research Pavilion and NTSC buildings in Research Park. We demonstrated this capability to PM-TRADE during the January 1991 review.

Polygon priority was an issue which had to be solved during the development of the *Flight* to ESIG formatter. The ESIG requires separation planes in its run-time database for correct viewing. Separation planes are created as a post-processing operation between MultiGen and the ESIG tools. We initially used semi-automatic routines provided by Software Systems for developing separating planes, the Software System's routines may be replaced by VSL-developed software during the project's second year. Further work is still needed here, but we have successfully generated separating planes in the Research Park database.

Project 2851: VSL is tracking the progress of the Air Force Project 2851 (P2851) since the MIDB project goal of developing a database development environment must be relevant to future P2851 databases as well as existing IG databases and technology.

Curt Lisle attended and presented briefly at the I/SWG in January 1991 at PRC, McLean, VA. The GTDB prototype production facility is almost complete and will be producing a number of GTDBs over the next eighteen months. VSL has been selected as an evaluation sight for run-time databases made from GTDBs.

VSL has proposed to PRC (the P2851 contractor) that VSL be selected to actually convert a single GTDB into run-time databases for the SIMNET and ESIG-500. If we are selected, the database would serve as a complete test case for the SimData Center software suite.

MIDB Focus for the Second Year

The SimData Center software will be exercised during the second year of the project as each prototype formatter is completed. We will demonstrate the system by using it to develop and convert a database for display using at least the BBN SIMNET and the E&S ESIG-500.

SIMNET Databases: VSL will focus on developing the formatter between *Flight* and BBN's S1000 environment during the second year of this project. We have already begun studying the intermediate formats created during the several step development process used by the S1000 tools. Once formatter prototypes are completed, they will be tested using MultiGen terrain databases and polygonal models.

ESIG Databases: With the ESIG formatter nearly complete, we can begin exercising this interface with a variety of databases to determine the best design methodologies when constructing databases for viewing on the ESIG. The second year may include phototexture application to ESIG terrain if we acquire appropriate imagery from P2851 or other sources.

Project 2851: If PRC grants our proposal, we will be converting a GTDB for display on our IGs using the SimData Center software. This effort would convert a complete database involving terrain, culture, and moving models and provide a complete system test (from input to display on both IGs).

Monthly Report June 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Accomplishments

1. Brian Blau has been in Contact with Pedro Ramos of General Electric in Daytona Beach about obtaining images of Indian Springs AFB in Nevada. Pedro indicated that GE would possibly be able to provide IST with these images along with other images that they have used in the Rapidly Reconfigurable Database Project. These images would be used as test cases for the software being developed for this project.

2. A meeting of the research group, which consists of Dr. Mubarak Shah of UCF's Computer Science Department and Dr. Kevin Bouyer of USF's Computer Science Department will be held during the first half of July. At this meeting we will discuss the timeline for the remaining 6 months of the project and ideas for follow on work.

3. Brian Blau has completed a timeline for the remainder of the project. It is included with this report.

Problems

There are no problems at this time.

Monthly Report: June 1991

Project: Multiple Image Generator Databases (MIDB)

Project Lead: Curtis Lisle

Accomplishments: Several separate efforts are underway within the MIDB project. Highlights of the past month are listed below by category.

1. SIMNET Databases: The S1000 Model Viewing tool has been completed. It allows interactive viewing of models using the IRIS's mouse to position the camera and zoom in or out. The Research Park database was successfully ported to the SIMNET system. It was evaluated by driving the M1 tank on the database. We are now studying the terrain and USO (roads, rivers, treelines, canopies) data formats in order to import this data into S1000.

2. Project 2851: A revised technical and cost proposal was sent to PRC for our subcontract work involving the conversion of GTDB data for our IGs at IST. We will begin development of this conversion software during the month of July.

3. NOSC: Curt Lisle met with Kevin Boner of the Naval Ocean Systems Center. NOSC is interfacing an unmanned air vehicle simulator to the SIMNET network. IST provided information about the SIMNET database formats to help them get database compatibility. The NOSC effort will be the second (after PRC, Rockledge with the NLOS project) to interface an outside simulator to the SIMNET network. IST has provided technical assistance to both of these groups.

4. Attached Report: Per the request of our COTR, a summary status report for the MIDB project is included.

Problems:
none at this time

UNIVERSITY OF CENTRAL FLORIDA

INSTITUTE FOR SIMULATION AND TRAINING

12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progess Reports for Visual Database

Date: 1 July 1991

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports and Cost Reports for Task 1 and 2 for the May 1991 time period are forwarded for your review and/or approval.

If you have questions, please contact me at 658-5000.

Sincerely,

Ernie Smart

Ernie Smart
Program Manager

PREPARED FOR:

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ORLANDO, FL 32826

CONTRACT N61339-90-C-0042, CDRL A002

BAA 89-01

GED Data Center Report
May 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
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Visual Database Research and Development
Task 1: Rapid Production of Geospecific Databases

Report A002: Description of Geospecific Data Processing Center
May 1991

Brian Blau, Lead
Visual System Laboratory
Institute for Simulation and Training
Orlando, Florida

Overall Activities

The activities of this project can be described in four broad areas: the acquisition of skilled personnel in key technical areas to support the Geospecific Data Processing Center (GeoData Center); the acquisition of hardware and software to support the complex activities in rapid production of databases; automatic production of terrain databases and technology transfers to industry.

Skilled Personnel. The Visual Systems Laboratory (VSL), in support of the Geospecific Data Processing Center has staffed itself with highly qualified personnel which are trained in the speciality areas of computer graphics, computer vision and image processing. Dr. Michael Moshell, who leads VSL has 20 years experience in the computer and physical sciences. Brian Blau, Curt Lisle and Ron Klasky have their Masters of Science in Computer science and each has experience in computer graphics. Klasky has additional experience in image processing and astronomy and Lisle has additional experience in low-level design of computer image generators.

The quality of the personnel listed above is enhanced by a pool of students from the Computer Science Department at the University of Central Florida. This department has a nationally recognized program with excellence in parallel computation and VLSI design. Most recently, their student computer programming team placed fifth in an internationally recognized programming contest. One of the programing team members is now employed at VSL.

Hardware and Software at the GeoData Center. Over the past year, the VSL has acquired software and hardware necessary to support the complex tasks involved in the production of databases. The following list summarizes the capabilities of the GeoData Center :

Image Generators

These machines have the capability to display geographic databases in three dimensions at real-time update rates.

VSL has the **ESIG 500** as its highest powered rendering engine. Databases from multiple sources can be built on support machines and then downloaded to the ESIG for display. Additionally, **SIMNET's Image Generator** from Delta Graphics is available for viewing more customized models and databases

The **Silicon Graphics Power Series** is a new addition to VSL which will enhance the capability to rapidly see low fidelity simulations. This is an excellent platform for visualization of low detail and low band width databases. Because this platform is a workstation, it is easily reconfigurable and will host many different software systems.

Image Processing Software

The GRASS image processing system, in conjunction with the **KUTRTA** digitizing tables, is being used to generate IG databases. Sources include DMA DTED/DFAD, satellite images and maps. These sources are combined in GRASS and written to a script file for use in the **ANIM** object animation system. Additional routines exist for exporting this data to the **Multigen** system, which is a tool for building image generator databases.

Modeling Software

The software packages **ElectroGig**, **AutoSolid**, **Alias**, **S1000** and **Geometric Modeling System** are useful when building custom image generator database models. Specifically, S1000 and Multigen has been used to build models for various industrial partners and projects tasks. These packages give the GeoData Center an ability to quickly build databases to customer specifications. These databases can then be transformed into the appropriate formats to be displayed.

Additional Software and Hardware

The VSL has two Sun Sparc workstations for use in the GeoData Center. These machines are general purpose UNIX computers that run at very high clock speed. This gives the GeoData Center the ability to perform complex tasks required for database construction.

Additionally, VSL has the ability to read and display DMA **DTED/DFAD** databases. Many of the software packages mentioned above have this feature which gives the GeoData Center additional capabilities to build geospecific databases.

Automation of Terrain Database Production. One of the main goals of this project is to determine unique and efficient methods for automatic and semi-automatic constructions of databases for image generators in support of some standard database interchange format. The GeoData Center has

the capability to build databases in several formats and continues to add flexibility to this process.

Using the Multigen and GRASS systems mentioned above, the GeoData Center can take raw input data, such as DMA DTED/DFAD, remote sensing, maps and photos and create individual databases which are at first specific to the hardware and software platform. Additional support comes from human modelers, which is now the only way to actually integrate all of the data. In the future, the integration of the databases will be automated by the use of intelligent software which will analyze the attributes of the data and then determine how the end databases need to be combined to form the standard database.

Additionally, VSL has developed a series of software packages which can extract useful 3D information from images. One package can recover depth from stereo images and the other package can recover building information from shadows. Both of these packages have been documented in the monthly reports for this project.

Technology Transfer

GeoData Center Technology Transfer: The GeoData Center, when complete at the end of the second year of this project, will be a toolset which creates computer representations of regions of geospecific terrain. Digitized terrain technology is attractive to a variety of industrial companies and government organizations. VSL has already begun relationships which will make this technology available to them.

VSL is beginning a relationship with the Army Engineer Topographic Lab where we will be cooperating with them in the development of geospecific database technology for simulators. VSL has already been funded by Martin Marietta to produce software prototypes which realistically display geospecific terrain in a simulator using **Continuous Levels of Detail** to minimize the number of polygons needed while preserving terrain features like ridge lines, contours, etc. VSL will be serving as a demonstration site for Project 2851 standardized databases as they become available over the next eighteen months – providing the simulator industry with an independent organization with expertise in this future database format. Project 2851 format databases are required for all new military training contracts involving Computer Image Generators.

As this project progresses, VSL will continue to look for avenues to make this technology available to interested organizations.

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CONTRACT N61339-90-C-0042, CDRL A004

BAA 89-01

Sample Data Base demo with Report
May 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
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Visual Database Research and Development
Task 1: Rapid Production of Geospecific Databases

Report A004: Sample Database Demonstration and Report
May 1991

Brian Blau, Lead
Visual System Laboratory
Institute for Simulation and Training
Orlando, Florida

Overview. During the first year of the project, there were two significant software developments which has lead the Visual Systems Laboratory (VSL) to build a standard database. These two software packages were built by Dr. M. Shah and Dr. K. Boyer of UCF and USF respectively.

Stereo and Shadow Analysis. Dr. Shah and his students have built a software system which when given a stereo pair, can determine the depth of the scene. Additionally, Dr. Boyer and his students have built a software system which when given an image of buildings and shadows can determine the height of those buildings. Both of these software packages have been documented in the monthly reports for this project.

Demonstration. This software will be used, along with commercial packages like Multigen and S1000 to build the sample database. On January 25 1991, VSL presented a demonstration of the capabilities which were developed during the first year of the project. Using both commercial software and applications developed for this project, the data flow from raw images to image generator database was shown.

During the second year, an additional databases will be built according to the guidelines proposed in this project.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
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CONTRACT N61339-90-C-0042, CDRL A003

BAA 89-01

Semi-Automated Integration Management System
May 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
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12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Visual Database Research and Development
Task 1: Rapid Production of Geospecific Databases

Report A003: Semi-Automated Integration Management System
May 1991

Brian Blau, Lead
Visual System Laboratory
Institute for Simulation and Training
Orlando, Florida

Overall Activities. The Visual Systems Laboratory, in support of the Geospecific Data Processing Center (GeoData Center), is developing an integration manager system which will direct the activities of several specialized software and hardware packages to produce standard databases.

Integration Manager. This system includes a master planning unit which helps to direct the overall flow of the data through the system. It can recognize different types of raw inputs (i.e.: DMA DTED/DFAD, images, photos), looks at their attributes and where they are located, and automatically determines their part in the building of the final database. In the course of building the database, there may be decisions that require the intervention of the human operator. At this point, the software manager will ask the operator specific questions about the configuration of the data as well as any ambiguities that may arise.

The decisions from the operator will be interpreted by the integration manager and the analysis of the data will continue. This interactive process will continue until the final goal of complete database is met. When the database is finished, it will be in the standard format selected prior to the start of the analysis.

Work to Date. The working aspects of this part of the project can be found in the various sections of the GeoData Center. During the calendar year 1991, many aspects of the integration manager will be incorporated together to make a semi-automatic system.

One of the main components that has been developed independently of this project is VSL's work in Virtual Reality. Their latest software development is Virtual Environment Realtime Network (VERN). This application gives its users the ability to communicate across heterogeneous platforms. This ability which will be included in the GeoData Center will add a level of flexibility that would not normally be part of a project such as this.

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042, CDRL A005

BAA 89-01

Final Report
May 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
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Visual Database Research and Development
Task 1: Rapid Production of Geospecific Databases

Report A005: Final Report
May 1991

Brian Blau, Lead
Visual System Laboratory
Institute for Simulation and Training
Orlando, Florida

Introduction

This document will describe the first year's work in support of Task #1, Rapid Production of Geospecific Databases of the Visual Database Research and Development project at IST which is funded by PM-TRADE.

The primary goal of this project is to provide a way to increase the productivity of human database modelers, especially those working with low-cost image generators. Accomplishing this goal involves the introduction of several new technologies which are usually not associated with simulator database construction. These technologies include Geographical Information Systems (GIS) and computer vision. These new technologies will be used to support the Geospecific Data Processing Center, an organization within IST which will include skilled personnel, software and hardware necessary for the rapid integration of digital geographic data, photographs, including stereo pairs, maps and charts.

Over the past year, there have been a number of specific sub-projects that were designed to get a better understanding of the simulator construction process. This included analysis of off-the-shelf software and hardware that already has taken this technology to the forefront. Implementations of stereo processing and shadow analysis helped in the evaluation of the main goal of this project. Additionally, there were consultations with industry officials who have insight into this arena of work. Their help along with the work done by Dr. Mubarak Shah at the University of Central Florida and Dr. Kevin Boyer at the University of South Florida has contributed to the success IST understanding of the simulator construction process.

Accomplishments

During the past year, there have been many aspects of this project which have contributed to the GeoData Center and each will be described individually. The cumulative effect of these efforts is also an important aspect which needs to be recognized.

During the first six months of this project, there was a concentrated effort to define the overall scope of this project, as well as define important

goals for the coming year. The following is a list of accomplishments which took place during the first year :

- **SIMNET Database** : Programs were written to read the SIMNET database. This is the plan view database which is located on the Mascomp computer. This effort was very successful, the data gathered from this experiment was valuable in many different aspects of this project. The code written was also used in other spin-off projects (Virtual Reality Demo @ I/ITSC 90, VSL's bulldozer and car on SIMNET terrain demo, Blau's masters thesis).

  Demonstrations of bulldozer on SIMNET terrain done at VSL during first quarter, 1991, used dynamic and microterrain techniques developed at VSL. Demonstration of another derivative of SIMENT software done at I/ITSC 90 in fourth quarter 1991.

  Problems in this area came about because VSL was unable to have access to the SIMNET CIG database. Dynamic terrain was to be put on SIMNET, but because of restricted access to the CIG database, work stopped in this area.

- **Univ. of Waterloo** : An image processing tool kit was acquired at nominal cost. Uses include general image processing functions and display functions. Documentation and source code is available.

- **Stereo Extraction** : Dr. Mubarak Shah and graduate students from the Computer Science department of the University of Central Florida started work on extracting image depth from stereo images. He specifically concentrated on using off-the-shelf algorithms as a working introduction to this field. Plans for the year include implementation of several known extraction algorithms, analysis of these algorithms to determine the focus of the second years effort.

- **Shadow Extraction** : Dr. Kevin Boyer and graduate students from the Computer Science department of the University of South Florida started work on extracting building height from shadows. Buildings cast shadows in an image, and through some geometry and computer vision techniques, the building height can be calculated. He specifically started to look at current algorithms to accomplish this goal. Plans for the year include implementation of several algorithms and analysis of these algorithms to determine the focus of the second years effort.

- **Literature Review** : Annotated bibliographies were constructed in the areas of stereo extraction and shadows analysis. These documents were submitted with the Quarterly report in June 1991.

- **Industrial Contacts and Logistics** : Information was gathered from the following sources: DMA data and the hardware necessary to read tapes, David McKeown at Carnegie Mellon for information about shadow extraction and images

The work done in the first six months defined clear goals that meet the expectations of this project. Specifically, the process of taking multiple inputs (ie: digital geographic data, single photographs, stereo images, maps, charts) can be integrated together for form accurate simulator terrain databases.

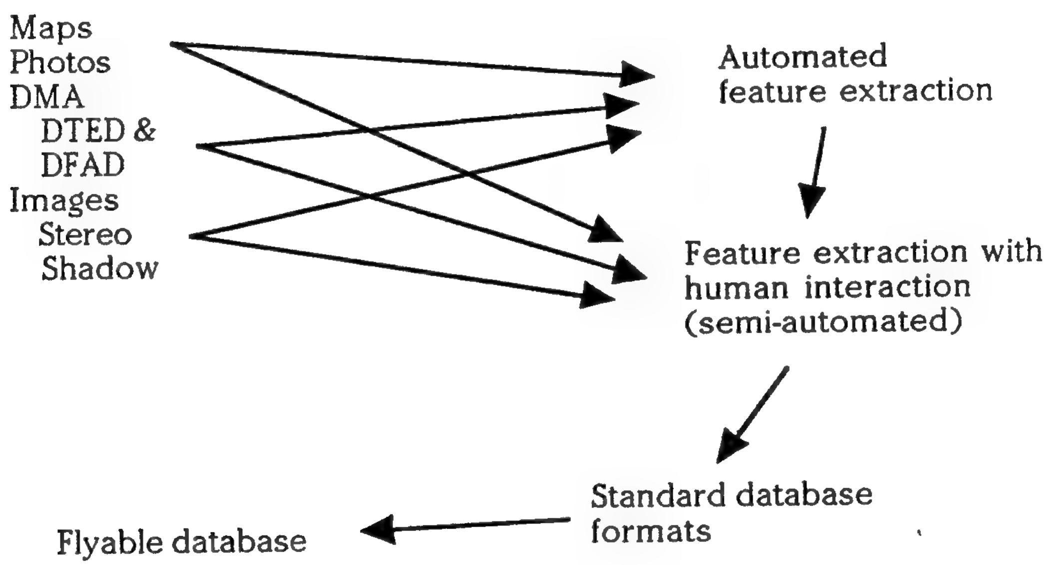


Figure 1. Path from raw data to flyable database

During the last six months of the first year of the project, efforts continued in the areas described above. The implementation was completed for the stereo extraction and shadow extraction algorithms. Additionally, industrial contacts were made during this period. The following is a specific list of work accomplished during the last half of the first year :

- **Stereo Extraction** : Dr, Shah and his students implemented three separate stereo extraction techniques. The output from all three is an image of depth values, where at an (x, y) location there is a corresponding depth. The problem here is that the (x, y) values are image coordinated, not actual physical values.

Normalized correlation method by Cochran and Medioni matches a point in the left image and right images and computes the disparity, which is then translated into height.

Sum of absolute difference method by Kayalap uses the difference of the correlation of points in the left and right images to compute the disparity. Again depth can be obtained from disparity.

Prazdny's method computes the correlation only at edge points in the image and it is based on a smoothness criterion. The disparity is computed at the edge points and then translated to depth values.

- **Shadow Analysis** : Dr. Kevin Boyer and his students have completed implementation of an interactive software package which lets the user choose a building to analyze. First the user is presented with an image which contains buildings, they are then instructed to trace a building and then its shadow. The height of the building is then computed and stored in a database file.

- **CAD Package for use with Stereo algorithms** : Chuck Campbell and Brian Blau have developed an interactive CAD style software package to interpret the output from Shah's algorithms. This software provides a view of the depth fields as a grid of posts, where the height of the posts correspond to the disparity between the left and right images. The user is then able to construct polygons using the tops and bottoms of the posts. The output of this program is a database of polygons.

- **Animated Fly Through** : The output from the interactive CAD software and the shadow extraction are inputs to Curt Lisle's ANIM Object Animation package. This software can be viewed as a generic object rendering engine. It is used to fly through the data that was created by both the stereo extraction and shadow analysis.

  The stereo depth extraction, shadow analysis, CAD interactive software and animated fly through were documented and demonstrated for the sponsors in January 1991.

- **Industrial Contacts and Logistics** : There has been contact with General Electric about their TARGET database construction toolkit. At the present time, IST is attempting to establish a working relationship which will benefit both organizations.

Images in both digital and picture form are being collected by VSL to support the GeoData Center. Along with this, continued research is being done in the areas of cartography and satellite imaging.

The following is a diagram of how the different aspects of database production fit together. It shows how stereo extraction combined with shadow analysis are combined through software and human interaction into a simulator database.

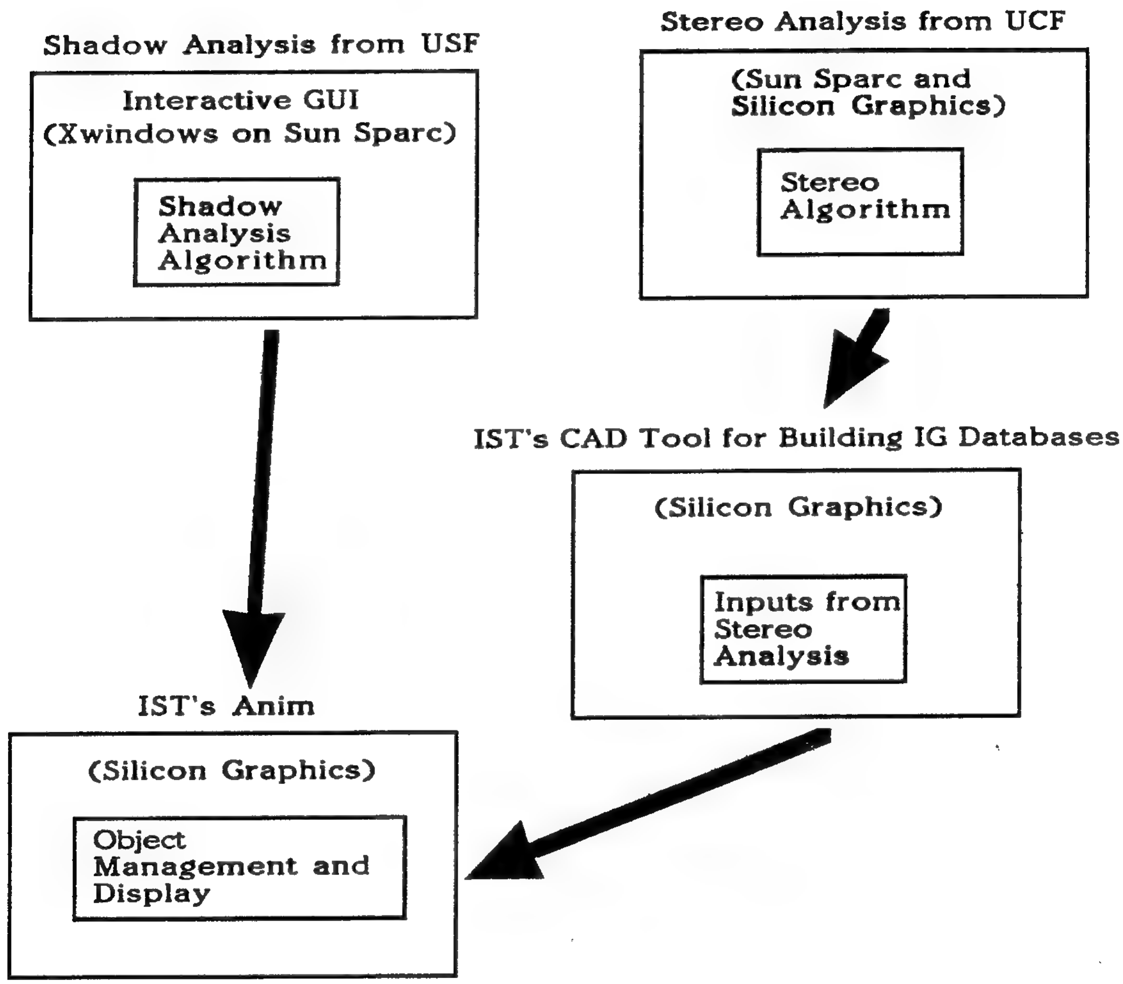


Figure 2. Stereo analysis, shadow analysis and database flythrough

Conclusions

After the first year of concentrating efforts on the rapid production of simulator databases, it has become apparent that there are many formidable tasks which lie ahead. There are issues that both Shah and Boyer will be addressing in the second year that will help solve some of the problems encountered while conducting the stereo and shadow research.

IST's Visual Systems Laboratory

- Army BAA Projects - Quarterly Review -

- Visual Databases
  Curt Lisle, Brian Blau, Ron Klasky

- Dynamic Terrain
  Michael Moshell

- Display Technology
  Richard Dunn-Roberts

Technology Transfer from Army Research:

- Virtual Environments and the Future of Simulation
  Michael Moshell

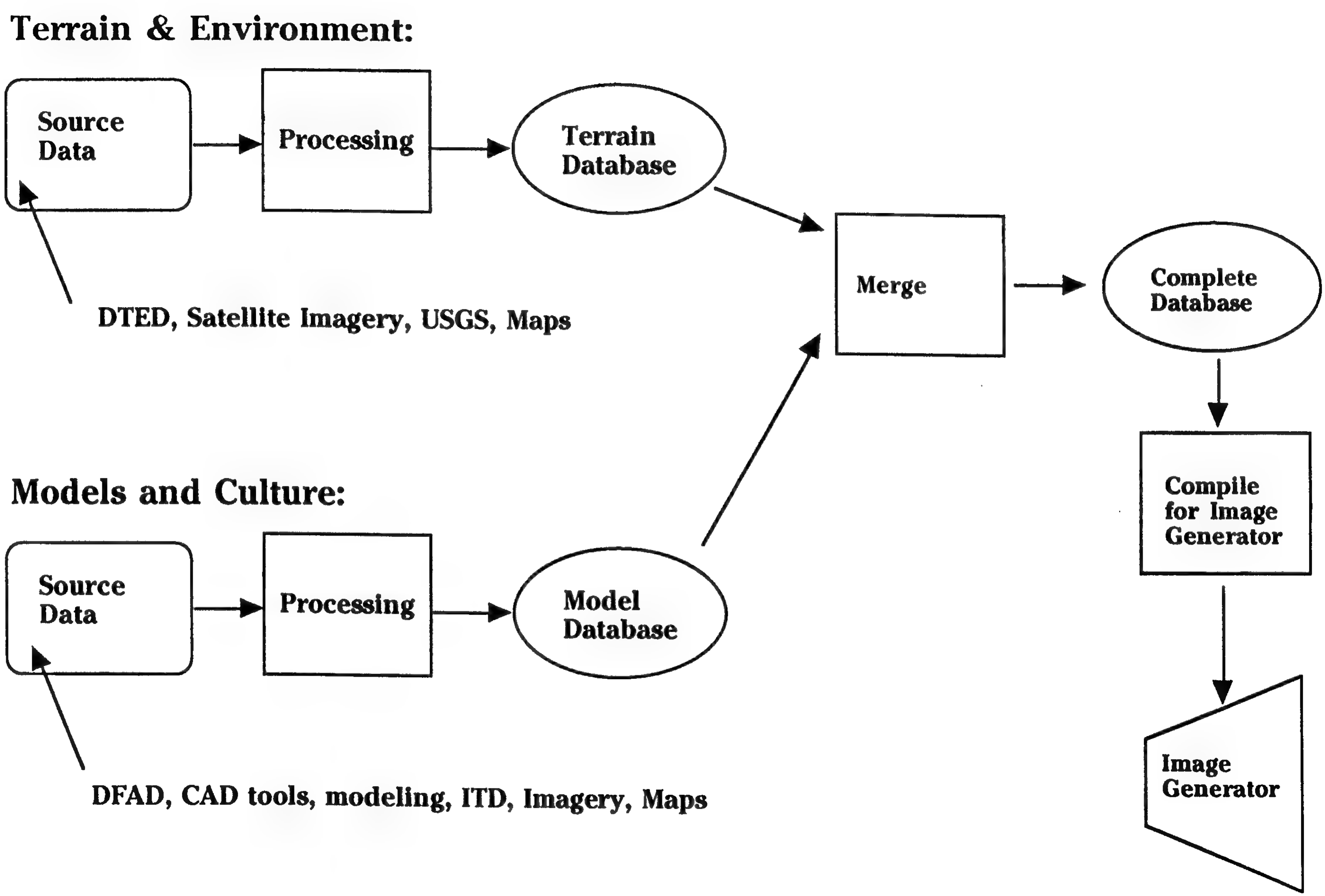
Visual Systems Laboratory
Multiple Image Generator Databases (PM-TRADE):

Goals:
1. Construct a database development environment which efficiently supports multiple Image Generators (IGs).
2. Minimize database development effort.
3. Begin to look at correlation issues between different IGs.

Completion Date: Feb. 1992

Objectives:	**Status:**
• Construct a formatter to support the ESIG-500 image generator	• Complete - undergoing test and evaluation
• Construct a formatter to support the BBN GT-101 image generator	• Partially complete - on schedule
• Develop suite of Visual database processing tools (SimData Center)	• Partially complete - on schedule
• Create demonstration database	• Start Sept.16, 1991

Visual Systems Laboratory
Visual Database Development Process:



Visual Systems Laboratory
Multiple Image Generator Databases:

Tools in the SimData Center:

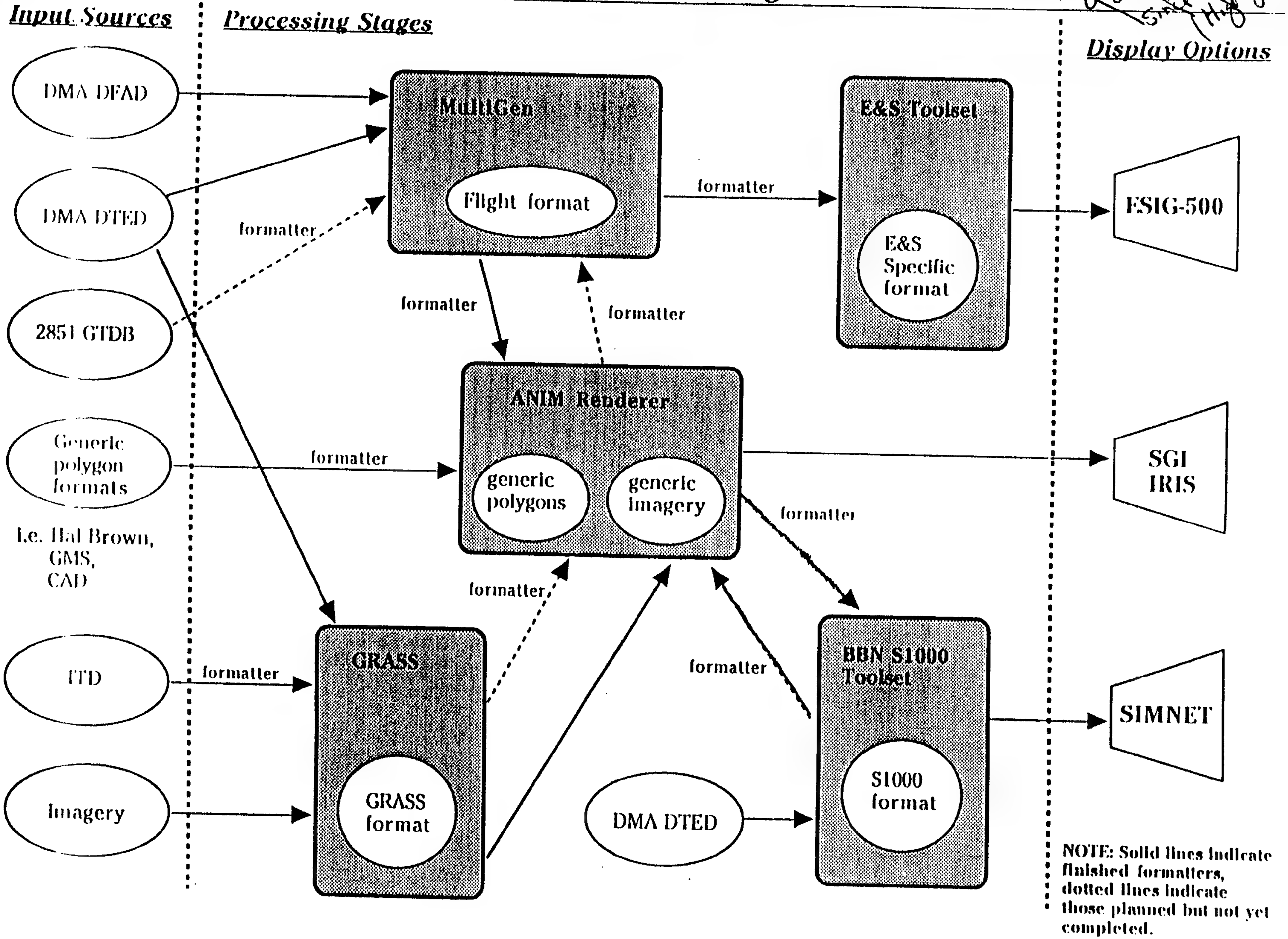
Off-the-shelf packages:

MultiGen (Software Systems, Inc.)
S1000 (BBN, Inc.)
GRASS (Core of Engineers)
E&S Compiler

Custom Development:

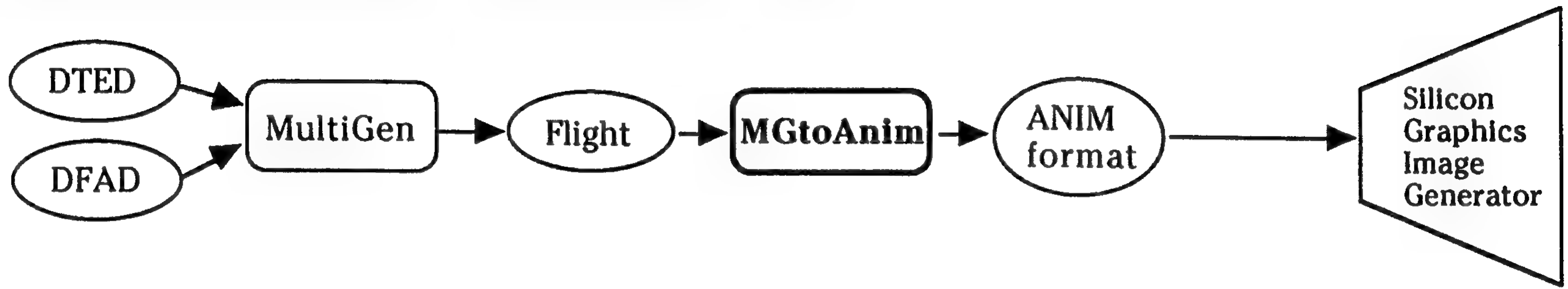
AnimAddPrior	AnimClip	AnimTri
AnimView	AnimTrans	AnimToMod
ModToAnim	MGtoAnim	AnimPolyFSize
AnimPlantCulture	AnimMerge	VectorToAnim
3DG1toAnim	GMStoMG	MGtoESIG
AnimToBBN	ANIM	AnimToMG
GridToAnim	AnimToESIG	dual
DispMod	AnimSize	

MIDB Project Dataflow Diagram:

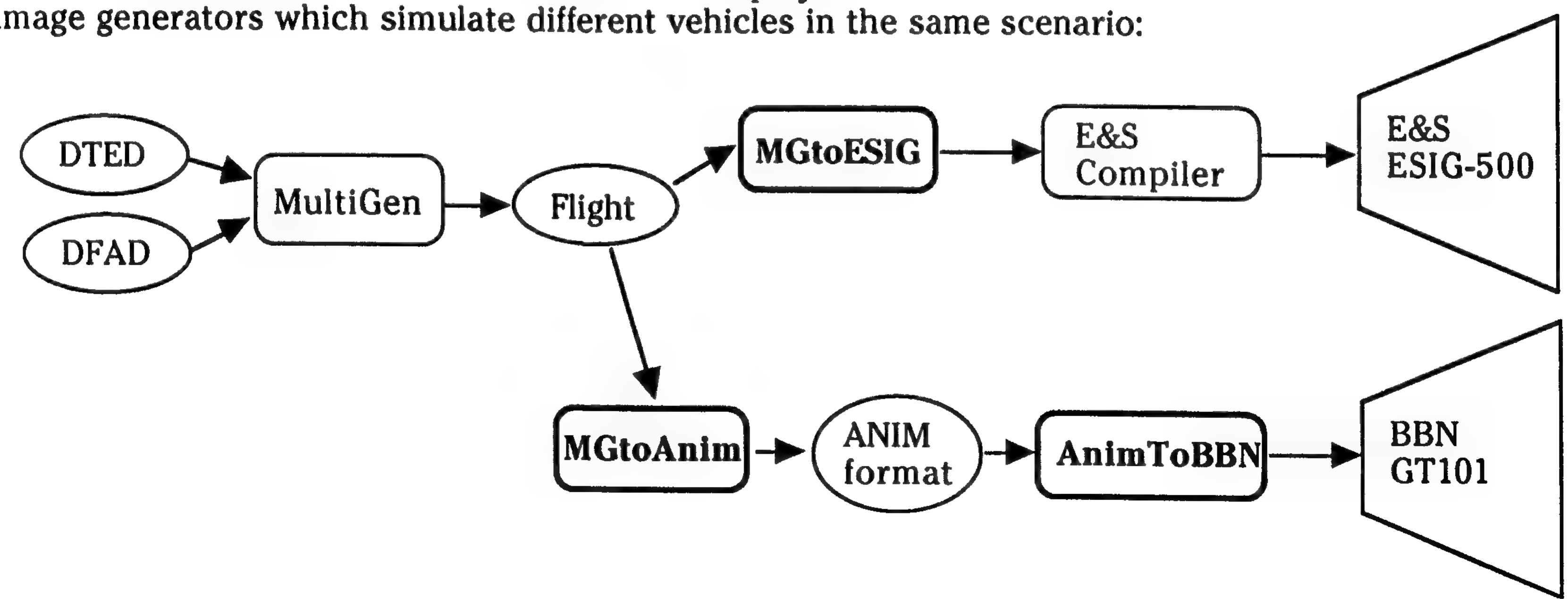


Visual Systems Laboratory
SimData Center Example Datapaths:

Low-End Trainer: the power offered by graphics workstations is sufficient for low to medium performance simulators:

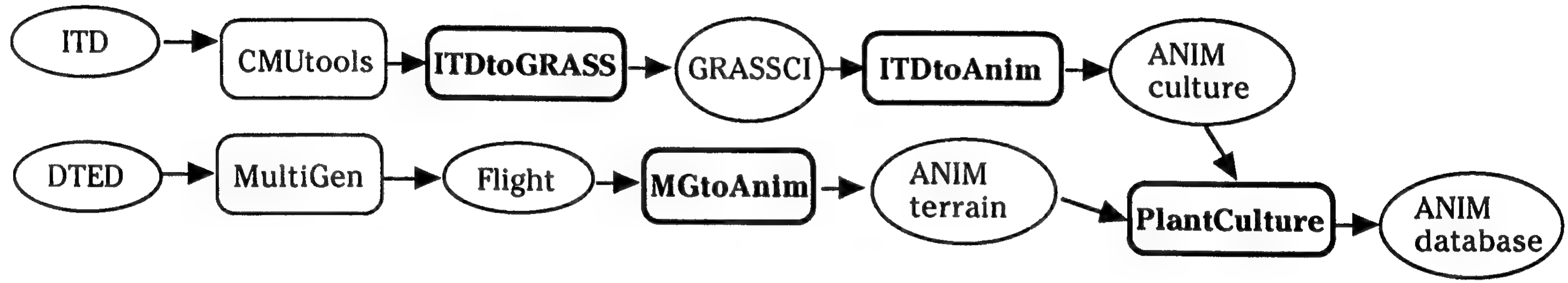


InterOperability: here the same database is displayed on two different image generators which simulate different vehicles in the same scenario:

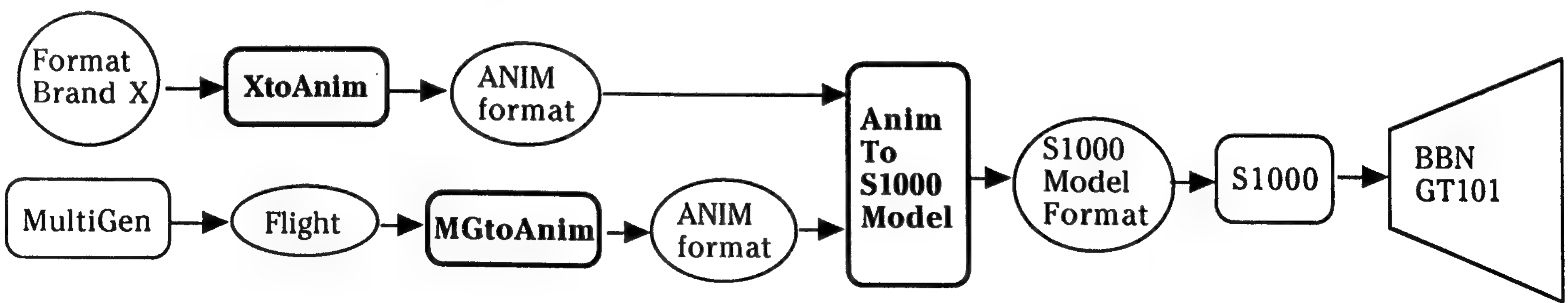


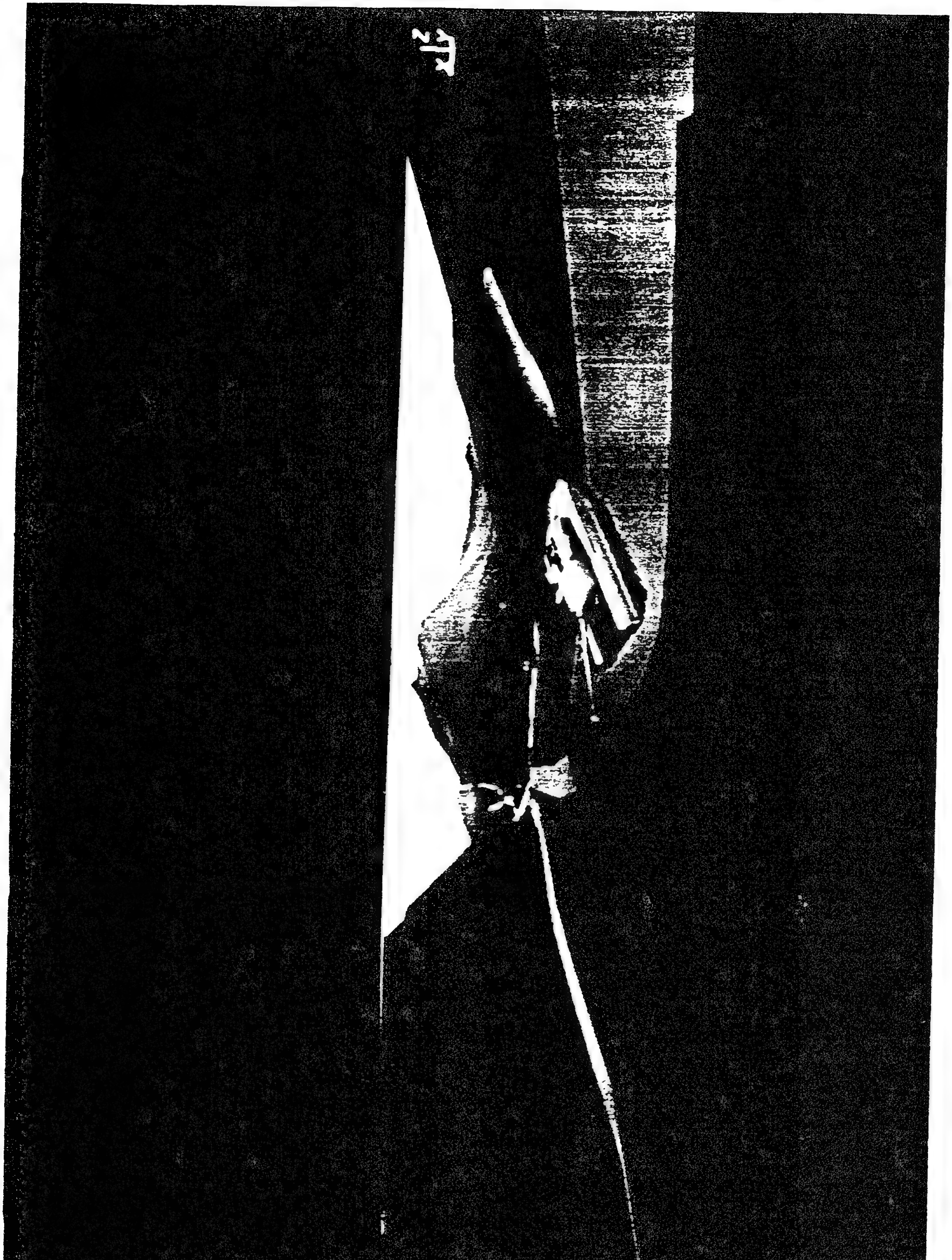
Visual Systems Laboratory
SimData Center Example Datapaths:

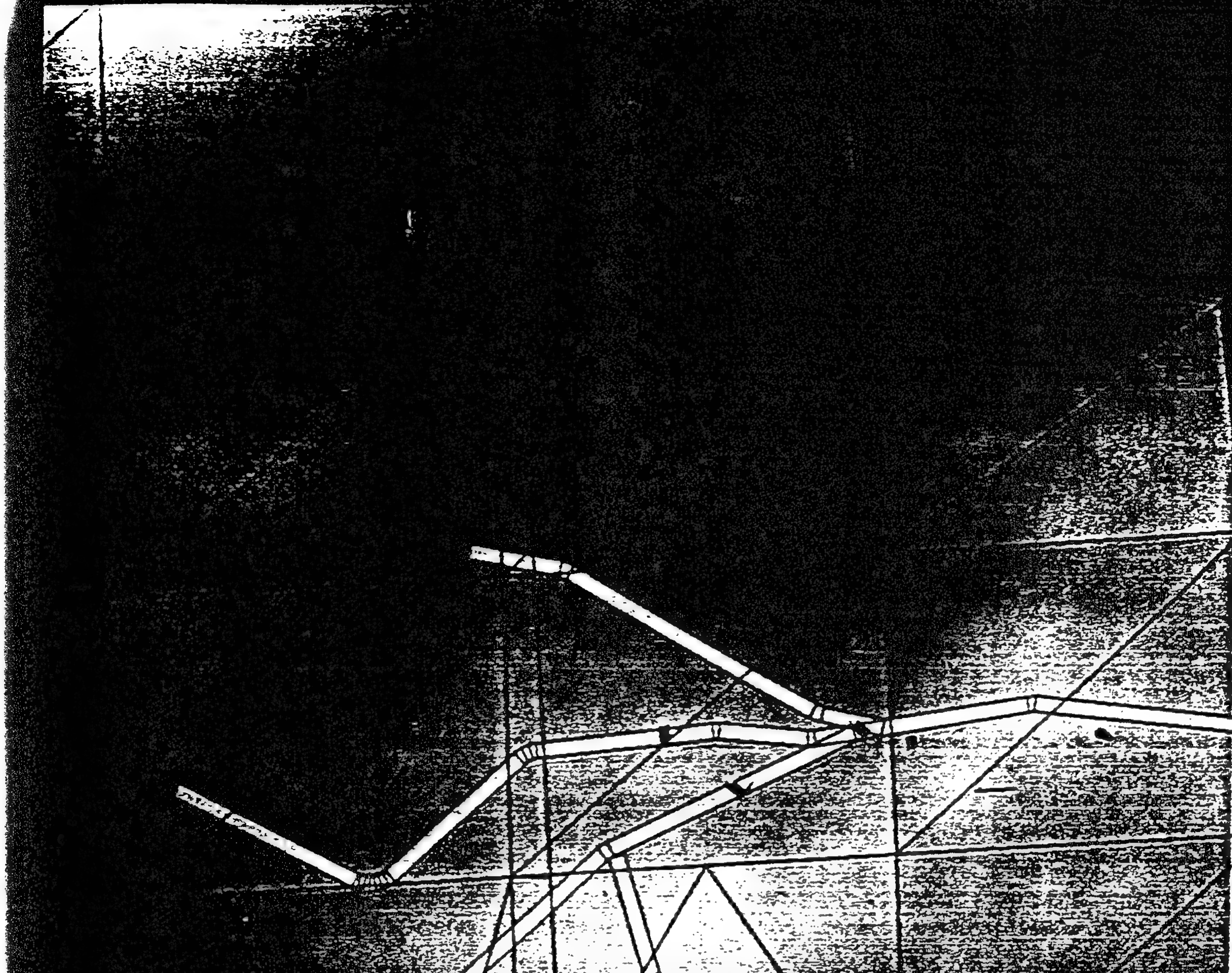
Culture Import: Cultural features are imported via ITD (Interim Terrain Data). Density can be adjusted before the culture is planted on the terrain:



New SIMNET Models: New dynamic models can be created or moved for the SIMNET environment from a variety of other CAD sources (MultiGen and Brand X shown):







Visual Systems Laboratory
Geospecific Database Generation:

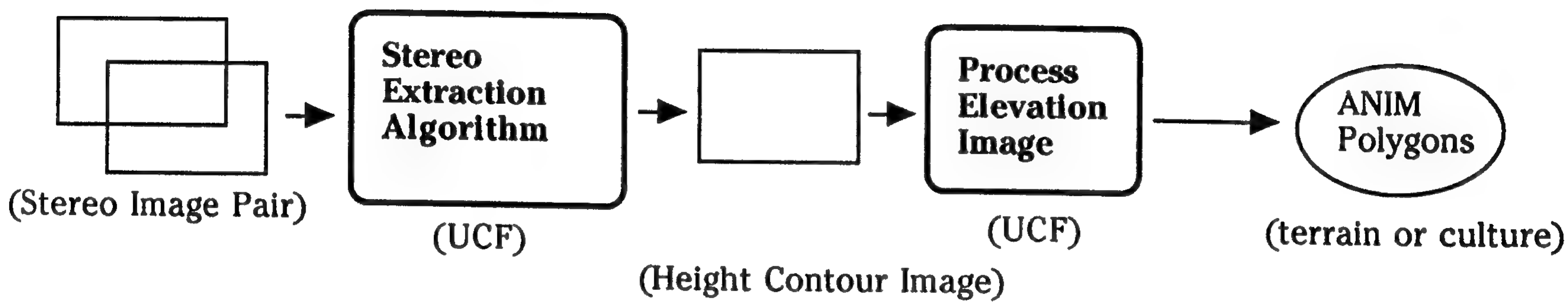
Goal: To research algorithms in two areas: extract elevation from stereo photograph pairs and extract the height and shape of buildings from low-altitude photographs.

Completion Date: Feb. 1992

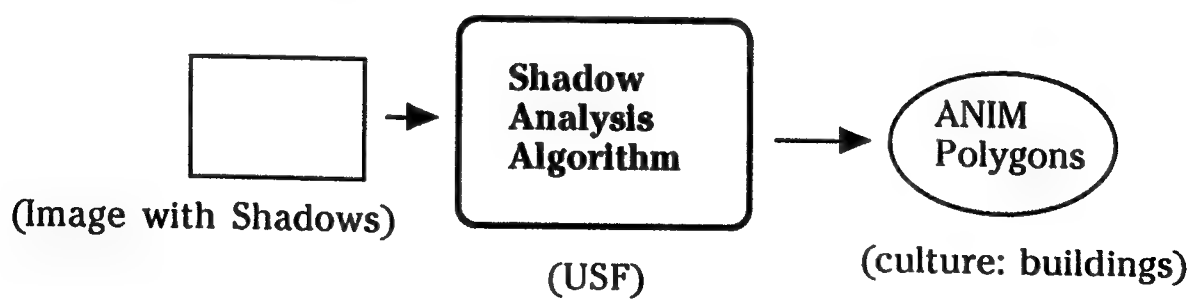
Objectives:	Status:
• Develop core image processing ability at IST/VSL.	• Complete
• Develop & demonstrate prototype stereo extraction and shadow extraction software	• Complete
• Complete software development and produce a final demonstration database	• On schedule

Visual Systems Laboratory
Geospecific Database Generation:

Stereo Extraction: Stereo pairs are processed to generate an image where intensity represents elevation. This is interactively digitized into polygons:



Shadow Extraction: A building outline and its shadow are outlined from an overhead photograph. The building polygons are automatically generated:



Visual System Laboratory
Project Status Summary - Image Generator Databases:

Feb. '90 - Aug. '91:	• Prototype formatters for ESIG-500 and SIMNET image generators. – COMPLETE
Feb. '90 - Aug. '91:	• Sixteen formatting tools developed – COMPLETE
Jan. '91 - Aug. '91:	• Prototype databases developed on MultiGen viewed on ESIG-500 and SIMNET. – COMPLETE
Sept. '91 - Nov. '91:	• Completion of remaining seven formatting tools for full dataflow functionality.
Sept. '91 - Dec. '91:	• Demo Database #1: Terrain from DTED and culture from ITD (demonstrate import from source data).
Oct. '91 - Dec. '91:	• Demo Database #2: Single building complex extracted from photographs (demonstrate automatic extraction).
Jan. '92 - Feb. '92:	• Evaluate databases & prepare final report.

Visual Databases: The IST Difference

- Animation & Modeling

  - ICM GMS (Solid & Polygonal)
  - ElectroGIG (Solid)
  - MultiGen (Polygonal)
  - Alias (Polygonal)

- Project 2851 Connection

  - UCF is sole University involved
  - P2851 GTDB evaluation subcontract

- Image Generators

  - Evans & Sutherland ESIG-500
  - BBN SIMNET

- Image Generator Experience

  - SIMNET Development site at UCF
  - Curt Lisle's architecture design with GE
  - Industrial Connections:
    Evans & Sutherland, GE, Software Systems

Unique Ability

Dynamic Terrain

GOAL: Investigate <u>feasibility</u> and develop <u>technology</u> to support *Dynamic Terrain* in realtime simulation.

> Dynamic Terrain: Earthworks, craters, tread marks, realtime hydrology, mine fields

Completion Date: 2/17/92

OBJECTIVES:	STATUS:
• Visualization	Report Draft in Review
• Database	Report Draft 50% complete
• Network Protocols	Research 80% Complete Report Draft 25% complete
• Physical Modeling	Research: Solid Objects 100% Hydrology 90% Soil Mechanics 40%

MAJOR TECHNOLOGIES	PAYOFFS	RISKS
Visualization		
• Realtime Modifiable Polygon Terrain Representations	• DT feasible on next generation IG's.	• Pushing IG costs beyond the reasonable?
Databases		
• Distributed Database Redundancy Control	• DT-based systems highly extensible	• Too hard to include existing simulators?
Networks		
• Communication within Distributed Computation for Complex Simulations	• DT Networking Requirements better understood	• Might clash with current technologies
Physical Modeling		
• Physical Modeling with Variable Fidelity Levels	• DT behaves realistically without extensive modeler effort	• Could require too many CPU cycles.

Four Dynamic Terrain Features

- Earthworks
  (Emplacements, tank traps, drainage, fords)

  The Need: Hull Defilade!

  The key problems: variable shape, lots of polys

- Craters
  (Bomb and Artillary impact, mines)

  The Need: Improved fidelity

  The key problem: LOTS of craters!

- Track Marks
  (Armor Tread damage to soil & vegetation)

  The Need: Evidence of enemy travel

  The key problem: LOTS of polygons, overlaid.

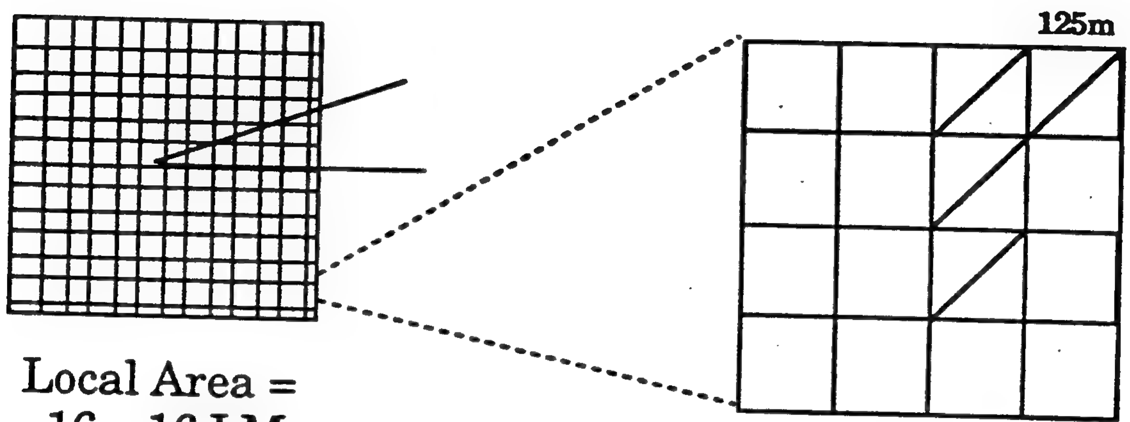
- Hydrology
  (Rain accumulating in low places, forming streams)

  The Need: Critical effect of precip on trafficability

  The key problem: Updating the whole terrain at once.

Feasibility of Tactical Dynamic Terrain

- SIMNET I: 300 polys for terrain, 400 culture, 300 models
- 20 degree FOV x 3.5 km =
  8.9 load modules (LM) x (≤32 polys) =
  up to 285 polygons in view.



Local Area =
16 x 16 LM

One LM=.5km^2
≤32 polygons

Let's imagine SIMNET II -

- 600 polys for terrain (300 static, 300 DT)

Now, HOW MANY

- Emplacements
- Craters
- Track marks

Could we reliably display?

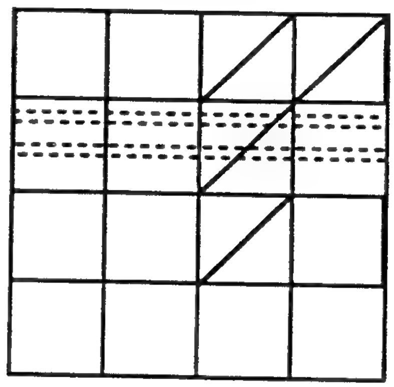
Feasibility of Tactical Dynamic Terrain

Track Marks

Case 1: Straight line travel

= Two polys per flat surface.

Each LM traversed would generate 8 to 24 new polys, for track marks.



Case 2: One maneuver every 5 tank lengths (40m)

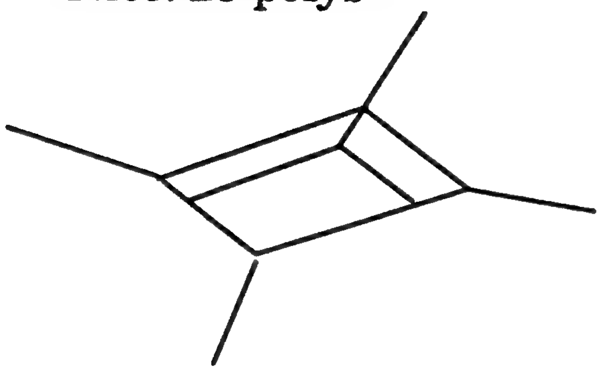
= (about) 12-15 maneuvers per 0.5 km (one LM) of which about half would cross poly bounds,

= 18 to 22 (*2) = **36 to 44 polygons per LM** traversed.

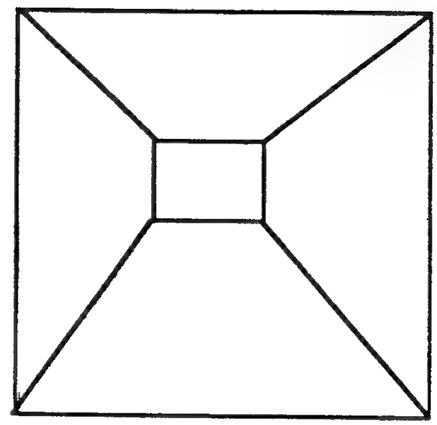
Feasibility of Tactical Dynamic Terrain

<u>Emplacements</u>

- Cheap: 9 polys
- Nice: 25 polys

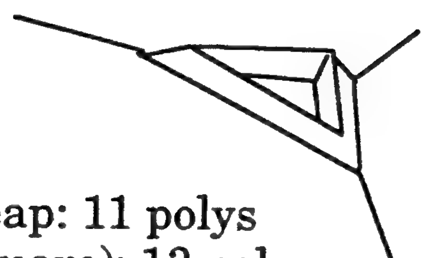


Perspective View

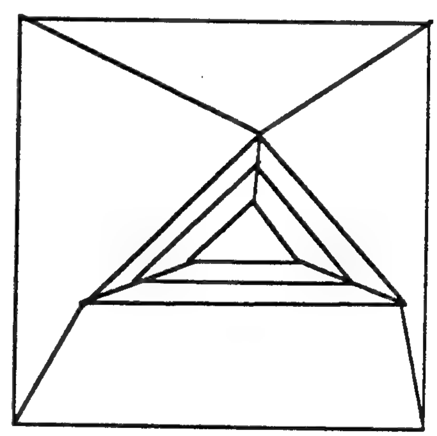


Top View

<u>Craters</u>



- REAL cheap: 11 polys
- Cheap (square): 13 polys
- Nice: 48 polys
  (Irregular hexagon)

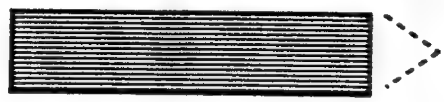


Feasibility of Tactical Dynamic Terrain

Levels of Detail:

- A 2m high crater (or earth berm) at 1 km range subtends 0.11 degrees.

- SIMNET's vertical FOV is about 7.5 degrees, 128 lines - so one pixel is 0.058 degrees high.

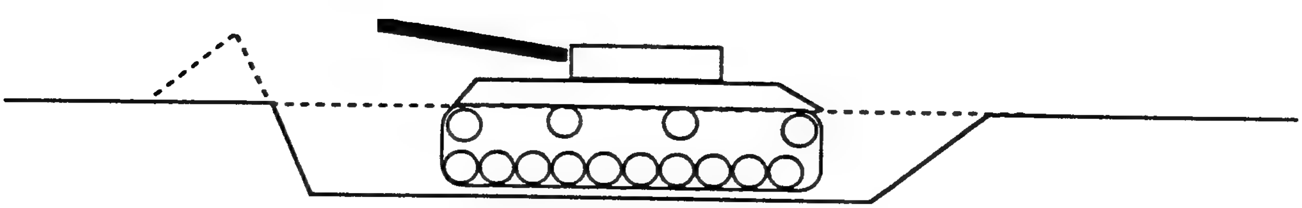


7.5 degrees/128 lines

- Thus, the 2m berm is two pixels high at 1 KM range.

- If one simply OMITS all DT features at > 1 KM range, this reveals at most 2 pixels of whatever's hiding behind them.

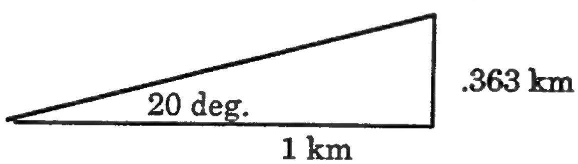
-- which should be standing in a hole, too... and will automatically be "partially buried" by the depth buffer, in the planar poly in coarse LOD.



Feasibility of Tactical Dynamic Terrain

Maximum Feature Densities with 600 polygons for Terrain
(300 for Dynamic Terrain AND 1 km LOD Control):

	Polys per Feature	Max. Nr. in FOV	Safe Density per KM^2
Emplacement - Cheap	9	33	183
Emplacement - Nice	25	12	66
Crater - Cheap	13	23	126
Crater - Nice	48	6	34
Track Marks - Straight	48/km	6 KM	34
Track Marks - Maneuvering	80/km	4 KM	20.6



Area = .18 sq km

And

- You can STILL "pick any three items" if we're using 1000 polygons for DT features.

Dynamic Terrain

Databases

- Hypothesis: Distributed DT databases should be partitioned;
  1/n - th of terrain on each of n processing nodes.
- Theory: Math analysis shows redundant systems saturating as n grows.
- Experiments: Underway, using Dynamic Terrain bulldozer as data source.
- Report: scheduled 10/91

Dynamic Terrain

Network Protocols

- Hypotheses:

  a) Physical objects & interactions are well modeled by object-oriented versions of the SIMNET Dead Reckoning paradigm

  b) Synchronization and high-bandwidth dataflow will saturate a shared bus broadcast-based network;

  - other architectures (e.g. hypercube) are more robust

- Experiments

  a) VERN - Virtual Environment Realtime Network

  b) Experimnents with Synchronized Message Combining on Hypercube

- Report - scheduled 11/91

Dynamic Terrain

Physical Modeling

- Hypotheses:

  a) Physical modeling will require <u>constraints</u> for realism
  b) Constraints are very cpu-intensive; use sparingly
  c) *ad hoc* techniques for special domains (water)

- Experiments

  a) Physical modeling of rigid solids: The PM/ANIM system
  b) Experiments in symbolic (Lagrangean) constraints
  c) Kass' realtime water models

- Reports

  - Working with John Farr, Waterways Experiment Station, on a report to include Soil Dynamics - 12/91 DRAFT

Project Status Summary - Dynamic Terrain

Visualization:

√ 1 Aug. 91 - Draft Report
15 Sept. 91 - Final Report

Databases:

√ 1 Sep. 91 - Draft Report
1 Oct 91 - Final Report

Networking:

15 Sep. 91 - Experiments Complete
15 Nov. 91 - Draft Report
15 Dec. 91 - Final Report

Physical
Modeling:

1 Dec. 91 - Experiments Complete
1 Jan. 92 - Draft Report
15 Feb. 92 - Final Report

Dynamic Terrain: The IST Difference

- Physical Modeling and Constraints
  - Chuck Campbell's M.S. Project
  - J. Burg, X. Li's Ph.D Projects
- Concurrent Computation & Databases
  - Kien Hua's IBM Insights
- Network Traffic Analysis
  - R. Vempaty's MCC Background; G++
- Graphical Analysis
  - M. Moshell's SIMNET and IG experience
  - IST's industrial connections

  BBN
  Evans & Sutherland
  GE
  Loral
  Martin Marietta

- Real-world Customers and Needs
  - Combat Engineers

Critical Mass

Head-Tracking and Head-Mounted Display Technology

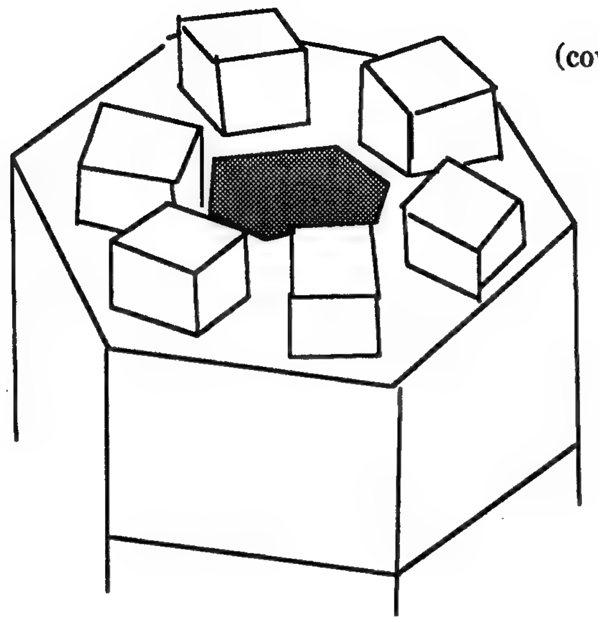
GOAL: Investigate alternatives to CRT screens and projectors for terrain-based visual simulation.

Completion Date: 2/17/92

OBJECTIVES:	STATUS:
• Head Tracking Display Experiment	• Experiment Done; Report in Prep.
• Head-Mounted Display on SIMNET	• On hold: SIMNET software access.
• High-Performance HMD on ESIG	• Demos in late September - Evaluation & Refinement, Dec. 91

Head-Tracking and Head-Mounted Display Technology

Major Technologies	Payoffs	Risks
• Polhemus position sensor software library	- Flexible, reusable tool	- Performance. <Evaluated: no problem>
• Head Tracking Display video switcher	- Quicker and cheaper than physically rotating cupola	- Integration with SIMNET software <jittery transitions>
• EyePhones (2 kinds) - VPL *EyePhones*™ - Howlett's *CyberFace*™	- More portable; cheaper than dome displays - More of an immersion experience	- Occlusion of in-cockpit vision - Mass on head - Low resolution



(cowling not shown)

Head Tracking Display Experiment

VSLB90.17-08

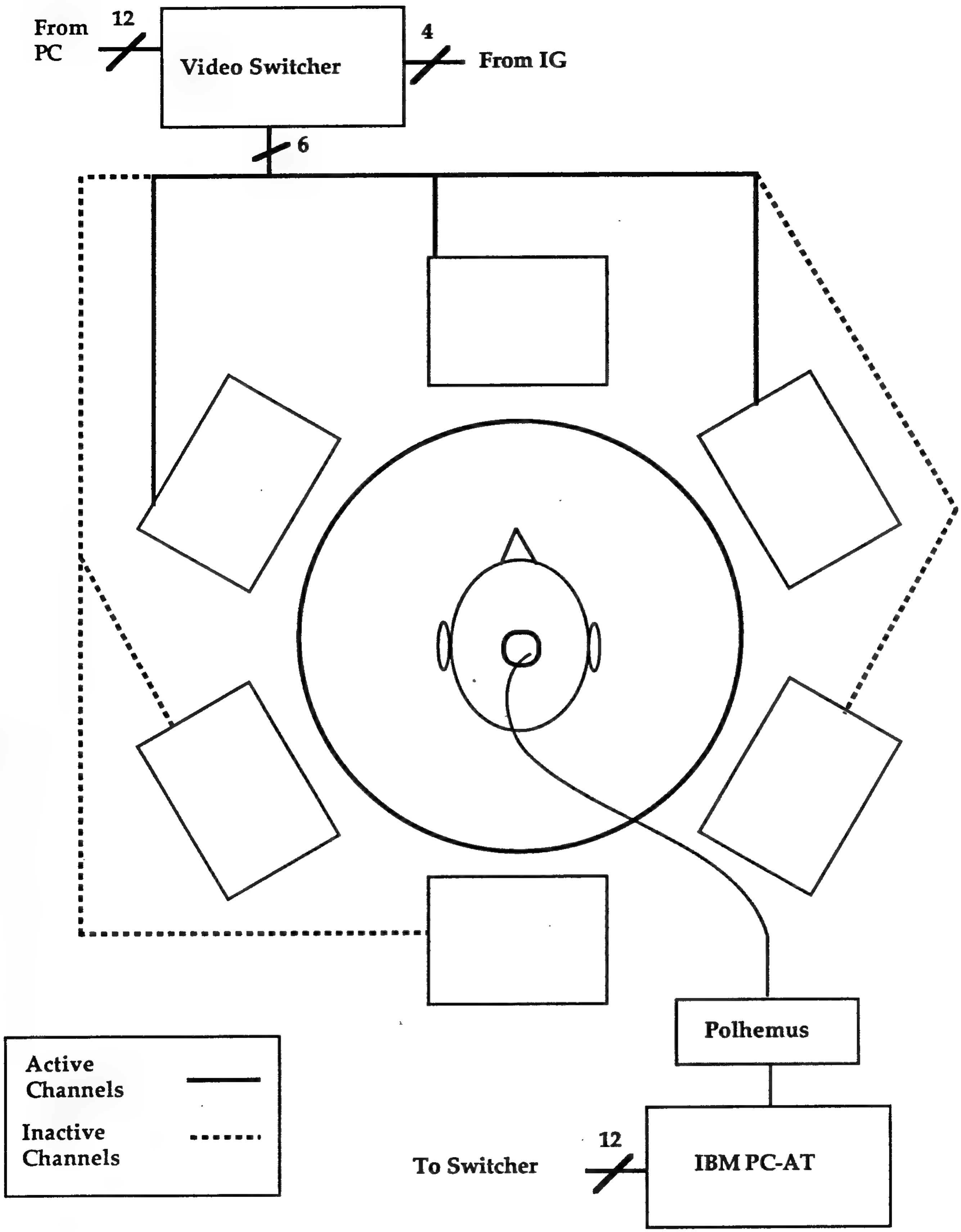


Figure 1. Head Tracking Display

HEAD-TRACKED CUPOLA DISPLAY EVALUATION

Experimental Design

EQUIPMENT \ TASK	TERRAIN REASONING	TARGET ACQUISITION
HEAD-TRACKED	C1 SUBJECTS 1-16	C2 SUBJECTS 1-16
STANDARD ROTATING CUPOLA	C3 SUBJECTS 1-16	C4 SUBJECTS 1-16

Preliminary Results - Terrain Reasoning (N=12)
(time between checkpoints 2-3)

MEDIANS BY SIMULATION AND COURSE

SIM/COURSE 1	SIM/COURSE 2	HTD/COURSE 1	HTD/COURSE 2
253 sec. (R: 206-999)	268.5 sec. (R: 209-338)	238 sec. (R: 173-999)	221.5 sec. (R: 180-312)

MEDIANS BY SIMULATION

SIMNET	HTD
268.5 (R: 206-999)	225.5 (R: 173-999)

MEDIANS BY COURSE

COURSE 1	COURSE 2
238 (R: 173-999)	233.5 (R: 180-338)

Preliminary Results - Terrain Reasoning (N=12)
(time between checkpoints 1-2)

MEDIANS BY SIMULATION AND COURSE

SIM/COURSE 1	SIM/COURSE 2	HTD/COURSE 1	HTD/COURSE 2
156 sec.	142.5 sec.	185 sec.	162.5 sec.
(R: 128-207)	(R: 129-236)	(R: 127-228)	(R: 122-221)
Mean: 161.3	Mean: 158.8	Mean: 175.2	Mean: 166.0

MEDIANS BY SIMULATION

SIMNET	HTD
144.5	177.5
(R: 128-236)	(R: 122-228)
Mean: 160.1	Mean: 170.6

MEDIANS BY COURSE

COURSE 1	COURSE 2
171.5	145.0
(R: 127-228)	(R: 122-236)
Mean: 168.3	Mean: 162.4

Head-Tracked Cupola Display Research

Preliminary Results - Preference Means (N=13)

Scale: 5=impossible, 4=difficult, 3=moderate, 2=easy, 1=very easy

QUESTION	SIMNET	HTD
1.) Ability to perceive locations accurately	3.11	2.89
2.) Ability to identify surroundings	3.00	3.00
3.) Ability to maintain orientation and not get lost	3.0	2.67
4.) Ability to acquire targets without time constraints	2.67	2.67
5.) Ability to acquire targets under time pressure	3.44	3.00

None of these results were statistically significant.

6.) Which simulation was more difficult?

SIMNET= 6
HTD= 5
SAME= 2

7.) Were there any features about either simulation that you especially liked or disliked?

8.) Which simulation do you think would be the most beneficial for training?

SIMNET= 8
HTD= 4
SAME= 1

9.) Which simulation do you prefer?

SIMNET= 7
HTD= 5
SAME= 1

10.) Do you think that your performance and preferences would have changed if the head-tracked display did not have popping/flickering?

Yes = 11 No = 2

Display Technology: The IST Difference

- Head Tracking Display
  - Video Switching Technology, Dr. Kasparis (UCF EE)
- Object Oriented Tools
  - Polhemus Object in C++
- Leverage with Virtual Reality Project
  - ESIG HMD, R. Dunn-Roberts' M.S. Project
- Advancement of HMD Technology
  - T. Clark's DARPA Project
- Industry/Academic Contacts
  - University of Washington (Human Interface Technology Lab)
  - General Electric
  - Martin Marietta

Critical Mass

Virtual Environments

- <u>Presence:</u> the suspension of disbelief

  EyePhones, Correlated Sound, Free Motion

- <u>Interaction:</u> changing the world

  DataGloves, Spaceball, force feedback ...

- <u>Autonomy:</u> realistic automatic behaviors

  Simulated physics, weather, expert systems ...

BUT: We do these things ALREADY in simulation.

What's the Big Deal? Is it all Hype?

Virtual Environments

VE is Simulation's *break-out* into society at large.

An Analogy: VIDEO RECORDERS

Early 1970's:	Circa 1978:	Late 1980's
AMPEX 1" Video Recorders	SONY 3/4" U-Matic VCR	VHS 1/2" VCR
TV Studios	Schools and Universities, Industry	Every Home
Cost: $100k	Cost: $5000	$Cost: $250
Qty in the world: 2000	Qty in the world: 200,000	Qty in the world: 200 million

Virtual Environments

Realtime Simulation's evolution into "Virtual Reality":

Early 1980's	1991:	Late 1990's
High Fidelity Flight Simulators	SIMNET, High perform-ance Graphics Workstations (SGI & others)	Next Generation Video Games <u>(Virtual Reality)</u>
Government and Airlines	Universities, Industry	Everywhere
Cost: \$1 m to \$40 million	Cost: \$25K to \$500k each	Cost: <\$1000
Qty in the world: <1000	Qty in the world: 200,000	Qty in the World: 200 million

Virtual Environments

IST's Testbeds: *Hardware and Software:*	**Performance** Research and Development
High-Performance *Evans & Sutherland 500* *Harris NightHawk* *Howlett CyberFace* *$2 million*	**World-Class (50 hz)** Concept Formation System Integration Educational Prototyping
Flexible Testbed *Silicon Graphics WS* *ANIM and VERN software* *$100,000*	**Research-Level (12 Hz)** Software Experimentation Physical Modeling
Economy/Applications *486 PC-based Hardware* *AutoDesk <u>CyberSpace</u>* *$25,000*	**Minimal Motion (3-5 hz)** Commercial Applications in 1992 - Florida Businesses

Projected Milestones - Virtual Reality
(* = depending on funding)

High Performance

1 Oct 91 - Head Tracking Viewing System
1 Nov 91 - System Integration: "VR Compiler" spec
1 Dec 91 - Demonstration: virtual Ping-Pong

Flexible Testbed

1 Jan 1992 - VERN 2.0, ANIM/Containers Underway
1 April 1992 - Joint Demo for SIGGRAPH '92 with
Naval Post-Graduate School - ready
1 August 92 - SIGGRAPH Networking Show
<* -- 1992 Dynamic Terrain>

Application System

1 Dec. 91 - CyberSpace Software Arrives
1 Feb. 92 - Specification
1 June 92 - Partial Prototype Review
15 July 92 - Working System, Alpha Tests
1 October 92 - In Service (Beta Tests)
<* -- 1992 Florida High Tech Council >

Virtual Environments: The IST Difference

- Networking know-how and connections
- Unique EQUIPMENT (Donated, GFE, locally built)
- Student/Faculty creativity

  - "dataPaw" project
  - Educational applications
  - Film/CAD crossover - model building

- Industrial Partnership

  - Micron/Green (Gainesville)
  - Autodesk (Sausalito, CA)
  - Image Resources (Orlando)

- National Exposure

  - IST Visitors
  - VR Conferences

Critical Mass

PREPARED FOR:

PM TRADE
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both task by current and cumulative cost. The Progress Reports are by separate task.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation Databases for Multiple Image Generators

Cost and Progress Reports
June 1991

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 JUNE 1991

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST
LABOR	$254,480.34	$86,803.24	$167,677.10	$16,986.55	$6,767.84	$10,218.71
TRAVEL	$9,756.51	$3,797.70	$5,958.81	$1.00	$0.50	$0.50
OTHER DIRECT COSTS	$69,163.49	$34,581.75	$34,581.74	$7,720.06	$3,860.03	$3,860.03
INDIRECT COSTS	$135,594.11	$47,969.62	$87,624.49	$13,053.58	$5,639.99	$7,413.59
TOTAL EXPENDITURES	$468,994.45	$173,152.31	$295,842.14	$37,761.19	$16,268.36	$21,492.83

	CUMULATIVE HOURS	TASK 1	TASK 2
HOURS REPORTED			
PREVIOUS REPORT	12,608.00	4,316.25	8,291.75
CURRENT HOURS			
MOSHELL	0.00	0.00	0.00
SMART	12.00	6.00	6.00
SHAH	128.00	64.00	64.00
KLASKY	73.00	0.00	73.00
LISLE	120.00	0.00	120.00
MORIE	60.00	0.00	60.00
SAMKOWIAK	2.00	1.00	1.00
NELSON	80.00	0.00	80.00
BUCKLEY	81.50	0.00	81.50
GOEL	80.00	0.00	80.00
STARK	160.00	160.00	0.00
BLAU	160.00	160.00	0.00
MULLALLY	4.50	2.50	2.00
M SMITH	23.00	0.00	23.00
CARRINGTON	40.00	0.00	40.00
HICKS	14.50	14.50	0.00
TOTAL CURRENT HOURS	1038.50	408.00	630.50
CUMULATIVE HOURS	13646.50	4724.25	8922.25

Monthly Report July 1991
Geospecific Database Project
Project Lead: Brian Blau
Visual Systems Laboratory
Institute for Simulation and Training

Developments

1. The proposed meeting of the research group, which consists of Dr. Mubarak Shah of UCF's Computer Science Department and Dr. Kevin Bouyer of USF's Computer Science Department, to be held in mid July was postponed due to schedule conflicts.

2. The timelines for delivery of software from Dr. Shah and Dr. Bouyer is being formulated. Their updated image extraction software will be used to create the cultural features for the demo database CDRL. When the exact delivery dates are known, more detailed database construction plans will be made.

Problems

There are no problems at this time.

Monthly Report: July 1991

Project: Multiple Image Generator Databases (MIDB)

Project Lead: Curtis Lisle

Accomplishments: Several separate efforts are underway within the MIDB project. Highlights of the past month are listed below by category.

1. SIMNET Databases: Work continues on the SimData Center toolset. A Polygon Resizing tool was completed during the past month. This tools allows the polygons of a model to be "stretched" slightly to compensate for a limitation in the BBN GT 100 series architecture. A result of this is increased efficiency for model development in the SIMNET environment. Also see #3 below.

2. Project 2851: As was mentioned in last month's report, work has begun on the formatting program from P2851 GTDB to MultiGen. It will be written in Ada on the Harris Nighthawk computer. The converter is part of our subcontract work for PRC. This tool will be part of the SimData toolset when completed. We have not yet received confirmation of our subcontract award from PRC. Curt Lisle talked with Gene Clayton (PRC) on July 29 and was told that IST's proposal was acceptable to ASD, but no commitment was made as to whether this option to PRC's contract would be exercised.

3. NOSC: Curt Lisle attended a meeting about SIMNET database interchange formats hosted at the Naval Ocean Systems Center (NOSC) on July 18, 1991. This was a high-profile meeting for IST. A trip report is attached. All expenses for the trip were covered by NOSC.

Problems:
none at this time

Trip Report

Dates: July 17-19, 1991

Location: Naval Ocean Systems Center
San Diego, CA

IST Personnel: Curtis Lisle

Persons Visited: Kevin Boner (NOSC) 619-553-3558
Tom Tiernan (NOSC)

Distribution of report:

Kevin Boner (NOSC)
Gene Clayton (PRC/Project 2851)
Brian Goldiez (IST)
Ray Green (PM-TRADE)
Dr. J. Michael Moshell (IST/VSL)
Ernie Smart (IST)
Scott Smith (IST)

Purpose: The purpose of the trip was to attend a SIMNET database interchange format meeting at NOSC. Kevin Boner invited several major offices involved in the SIMNET system to meet in order to solve the Navy's short-term problems with the UAV program as well as the entire industry's long-term problem of database compatibility with existing SIMNET systems.

Meeting Attendance: This meeting was attended by approximately 25 people including the following:

Bob Clover (IDA)
Alex Gallico (CAE CSRDF)
Rear Adm. Lee Kollmorgen (DARPA Consultant)
Farid Mamaghani (BBN)
Lt. Cmndr. Dennis McBride (DARPA)
Alan Mitchell (BBN)
David Pratt (Naval Post-Graduate School)
Richard Sherman (Loral)
Rullell Ure (CAE Montreal)
Chuck Taylor (UAV-JPO)

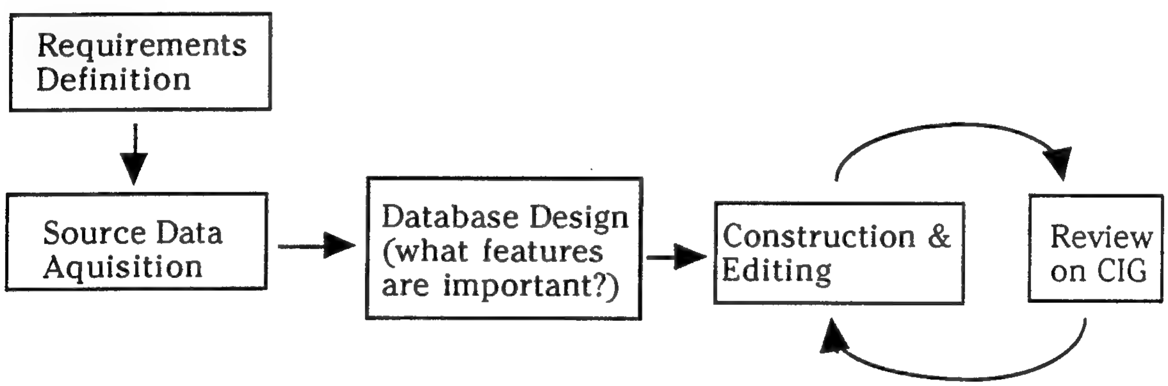
Itinerary: July 17 and July 19 were entirely spent in travel between Orlando, FL and San Diego, CA. All day July 18 was spent on site at NOSC. The entire group met between 8:00 am and 12:15 pm with a smaller more-technical meeting continuing on until about 5:30pm. I met with Kevin Boner to review the day's events after 5:30pm.

Meeting Summary

The following sections summarize the major ideas presented during the NOSC meeting described above. Where applicable, the presenter of the idea is mentioned.

Tom Tiernan / Kevin Boner (NOSC) -
Problem: - The UAV (Unmanned Air Vehicle) program has a technical block. The UAV system is hooked up to the SIMNET via a protocol translator, but the UAV CIG (Computer Image Generator) is currently not a BBN design. Database compatibility is the problem. How does the UAV program get the Hunter Liggett database and standard SIMNET models on a non-BBN CIG? Other databases are desired, also. Can standards be agreed upon to make future connections to SIMNET less painful?

Farid Mamaghani , Alan Mitchell (BBN) -
Database Development Process: DB (database) development process shown in diagram below. The S1000 tools do this process for BBN. ITD import to S1000 under development by LNK & Army ETL.



Basic steps to model-building:

1. Create Geometry
2. Build different LODs (levels of detail)
3. make broken versions of models (destroyed)
4. add color, texture, thermal attributes desired
5. compile into new DED (dynamic element database)
6. review model on CIG
7. map to vehicle ID on network (so network messages match model)

CIG Limitations to consider during design:

1. polygon count
2. DB complexity
3. model count in DED

4. memory capacity / disk capacity of CIG

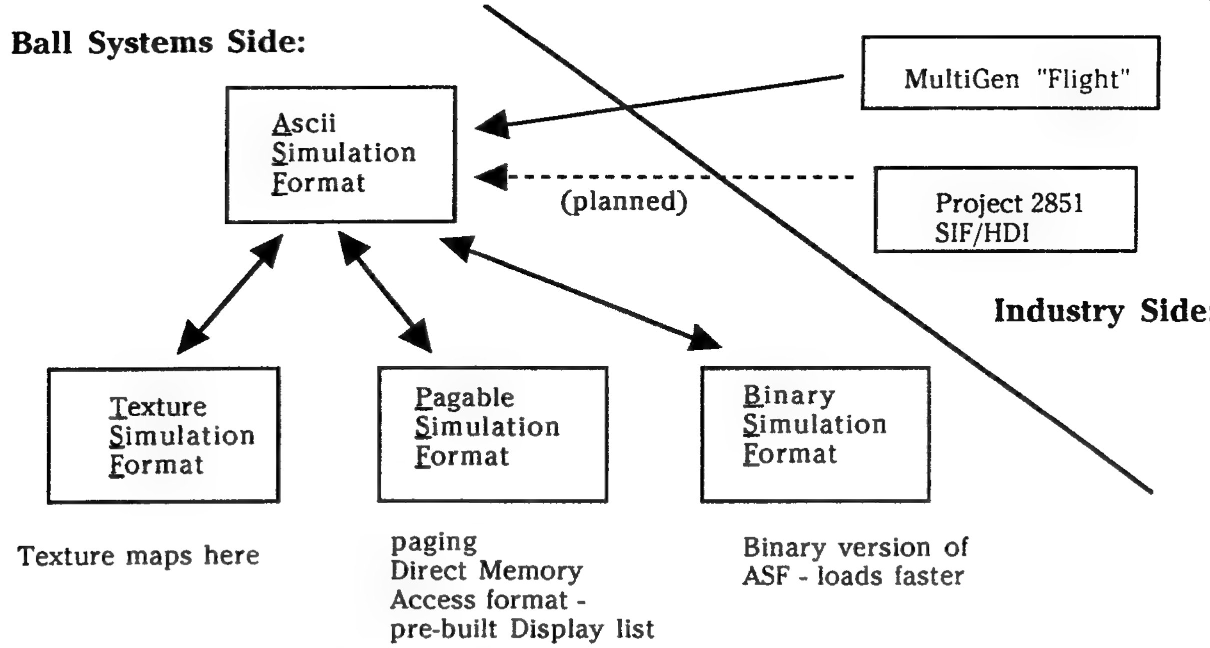
SDIS format: BBN created a public database format, called SDIS (SIMNET Database Interchange Specification). The acronym words were changed to "Simulation Database Interchange System" recently. The SDIS format was originally designed to support dynamic terrain and network interface (transmitting terrain changes across the network). SEF (SDIS Interchange Format) was initially an ISO standard which supported networking (ASN.1). This was hard for many users, so BBN wrote tools to ease access. The Application Program Interface (API) is available to help users get access to SDIS databases.

Future work at BBN: Areas that BBN would like to follow include speeding-up the API, compatibility between SDIS and Project 2851 data formats, better automatic extractions of model and terrain data from the SDIS formats, and importing alternative databases into the BBN environment using SDIS. Also distributed dynamic terrain and inputting intelligence data for mission rehearsal in a distributed environment.

BBN would like to cooperate with other industry or government groups to follow some of the future application areas. Additional funding will be necessary for BBN to address any of these future areas.

Gary Washam (Ball Systems Inc.) - Ball Systems purchased MegaTek. They are a small Image Generator vendor now.

Data Formats: Internal to the company, Ball Systems uses ASF (ASCII Simulation Format) which is generic and similar to MultiGen "Flight" format. (Author's note: IST is familiar with "Flight" format and has current projects involving this format). The following diagram describes their internal formats and their interfaces to the other formats in the simulation industry:



Problems with UAV Project: Ball Systems has no good way of getting the SIMNET databases over to their CIG platform. An SDIS translator was built, but didn't work very well. A small 8 kilometer x 8 kilometer SIMNET database was transferred with about two man-months effort. Ball would rather not go through this effort again.

Dan Brockway (Cambridge Research Assoc.) - He is personally doing most of the work with the Ball Systems CIG. He has gotten about 12 Hz update rate out of it with the small 8k x 8k database. Ball cannot page in "load module" sections of the database as the CIG moves around yet. Ball's architecture is still immature.

Dave Pratt (Naval Post-Graduate School) - Dave has been involved in the conversion of SDIS format. He's developed a networked simulator running on Silicon Graphics IRIS workstations. He converted SDIS database and models to get data for his simulator. Strengths of SDIS: flexibility and generality (it can hold many different types of data); drawbacks of SDIS: limited to triangles (no four or more sided polygons), not human readable, some polygons had normals reversed;

Discussion by the entire group: The following topics were discussed by the entire group during or after the presentations:

Project 2851 SIF/HDI format - The Tri-Service Project 2851 is specifying SIF/HDI (Standard Simulator Database Interchange Format / High-Density Input-output). This format is receiving fairly-wide industry participation. The idea of the Navy funding the remaining SIF/HDI development was discussed. This would allow the Navy to drive completion of the format design, making it serve as an industry-wide format for SIMNET databases.

George Lukes (Army ETL) was one of the strongest advocates of using the SIF/HDI format.

Using SDIS for terrain - The Navy Post-Graduate School (specifically, Dave Pratt) offered software tools to convert the entire 50 kilometer x 50 kilometer Hunter Liggett database into a simple, textual format which would be easier for Cambridge/Ball to use.

Transferring SIMNET models - Between 200 and 300 models have been developed by BBN for various SIMNET projects. A standard set of 114 models are installed at all the SIMNET-T (training) sites. These models need to be transferred over to the Ball Systems CIG. BBN said it could convert models to SDIS format, but would require funding for this effort. Curt Lisle (IST) said IST had many of the models and could provide software to convert them into a simple, textual format (similar to Dave Pratt) with minimal effort.

Final Recommendations: (Bob Clover) The following is the recommendations given to the Navy to solve the UAV program's problem:

Problem	*Solution Responsibility (short term / long term)*
1. Terrain	
A. Getting rest of 50kx50k Hunter Ligget	NPGS/ Ball-CRA
B. Converting other SIMNET DBs to SDIS	PM-TRADE (sub to BBN)
2. Models	
A. 40+ models already in SDIS	NPGS
B. 114 standard models converted to SDIS	DO to PM-TRADE (sub to BBN)
C. future models & building DEDs	CRA->ETL->LORAL (DO)
3. Updating Vehicle Map	PM-TRADE / Loral
4. Configuration Mgmt. (databases, S1000 software, DEDs, etc)	PM-TRADE / Loral

DO = delivery order
CRA = Cambridge Research Associates
NPGS = Naval Post Graduate School
ETL = Army Engineer Topographic Labs

Discussions with NOSC

After the meeting was over, I had some additional discussions with Kevin Boner (NOSC). It seemed that NOSC will attempt to become more self-sufficient for visual system database generation. We discussed several possible cooperative tasks including model development and interfacing IRIS workstations to the SIMNET network. All of this was just talk because we don't know how much is possible contractually, but Kevin's group at NOSC would like to work with IST if it is possible.

Discussions with BBN

Both Alan Mitchell and Farid Mamaghani expressed interest in providing the new S1000 tools to IST. I have since been in contact with a BBN engineer who is preparing a tape for IST. Alan and Farid will be in the Orlando area in the next several months and would like to meet to discuss further cooperative work between BBN and IST. Areas we discussed:

- X11 port of S1000 tools
- SDIS to SIF/HDI formatter
- co-development of S1000 tools

Summary

This was a high-visibility meeting in the simulation community (particularly the SIMNET community). I believe it was advantageous to both IST and NOSC that I attended. As described above, there are possibilities of funding from NOSC. Kevin Boner is planning a visit to IST on August 9, 1991. We will hold further discussions at that time.

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

PM TRADE
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMCPM-TND-ET

Subject: BAA-89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042

Enclosure: Cost and Progress Reports for Visual Database

Date: 2 August 1991

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Reports and Cost Reports for Task 1 and 2 for the June 1991 time period are forwarded for your review and/or approval.

If you have any questions, please contact me at 658-5000.

Sincerely,

Ernie Smart
Ernie Smart
Program Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

November 1992

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 NOV 92

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$340,403.30	$95,795.23	$244,608.07	$0.00	$1,869.22	$0.00	$1,869.22	$0.00
TRAVEL	$15,122.02	$3,749.90	$11,372.12	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$83,118.16	$14,414.07	$25,506.09	$43,198.00	($164.94)	$0.00	($164.94)	$0.00
INDIRECT COSTS	$181,085.57	$53,025.47	$128,060.10	$0.00	$942.40	$0.00	$942.40	$0.00
TOTAL EXPENDITURES	$619,729.05	$166,984.67	$409,546.38	$43,198.00	$2,646.68	$0.00	$2,646.68	$0.00

	CUMULATIVE HOURS	TASK 1	TASK 2
HOURS REPORTED			
PREVIOUS REPORT	19,670.25	5,187.25	14,483.00
CURRENT HOURS			
CORTES		0.00	5.00
FU		0.00	0.00
HORAN		0.00	12.50
LISLE		0.00	8.00
MARROU		0.00	43.75
PARRIES		0.00	57.50
SAMKOWIAK		0.00	3.00
SMART		0.00	13.50
TUGGLE		0.00	16.00
TOTAL CURRENT HOURS		0.00	159.25
CUMULATIVE HOURS	19,829.50	5,187.25	14,642.25

FUNDED	$640,081.72
EXPENDED	$619,729.05
	$20,352.67

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on November 1992 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB: A Ft. Irwin GTDB was received by IST. It covers a one-cell area containing the Ft. Irwin base camp. The Ft. Irwin database was converted from a GTDB to the MultiGen format the first try with no software changes at all! Further processing remains before the database is ready for import into S1000 (see next paragraph).

MultiGen to S1000 formatter: The new S1000 assembly tool which imports MultiGen format databases was received by IST this month and tested. It imported a small sample database but did not correctly import the ITSC database made of Hunter Liggett. After some experimentation, we found that the S1000 system imports a MultiGen flight format similar to but not exactly what our pipeline produces. The development of an additional conversion tool will allow us to process the Ft. Irwin database onto the SIMNET during December and early January.

Problems: None at this time

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12424 Research Parkway, Suite 300 ORLANDO, FLORIDA 32826

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: December 29, 1992

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the November 1992 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5014.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

December 1992

PREPARED BY:

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UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on December 1992 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB: As was reported in November, the GTDB of Ft. Irwin was received by IST and was converted to MultiGen format by our software successfully. When further processing was begun on the database, it was discovered that the unexpanded cultural features are difficult for our conversion software to process.

Expanding the culture and planting it is beyond the scope of what a formatter for the SIMNET IG from GTDB should have to perform. Therefore, we modified our parameter requrest to include fragmented, expanded culture and requested an additional GTDB from P2851.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 DEC 92

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$341,791.92	$95,795.23	$245,996.69	$0.00	$1,388.62	$0.00	$1,388.62	$0.00
TRAVEL	$15,122.02	$3,749.90	$11,372.12	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$83,238.40	$14,414.07	$25,626.33	$43,198.00	$120.24	$0.00	$120.24	$0.00
INDIRECT COSTS	$181,719.29	$53,025.47	$128,693.82	$0.00	$633.72	$0.00	$633.72	$0.00
TOTAL EXPENDITURES	$621,871.63	$166,984.67	$411,688.96	$43,198.00	$2,142.58	$0.00	$2,142.58	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	14,642.25	19,829.50
CURRENT HOURS			
CORTES	0.00	2.00	
LISLE	0.00	25.00	
PARRIES	0.00	20.50	
SAMKOWIAK	0.00	2.00	
SMART	0.00	14.00	
TOTAL CURRENT HOURS	0.00	63.50	
CUMULATIVE HOURS THRU 12/31/92	5,187.25	14,705.75	19,893.00

FUNDED	$640,081.72
EXPENDED	$621,871.63
	$18,210.09

UNIVERSITY OF CENTRAL FLORIDA

INSTITUTE FOR SIMULATION AND TRAINING

12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: January 29, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the December 1992 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5014.

Sincerely,

Ernie Smart
Program Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

January 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on January 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB: As delivered in the first GTDB, the cultural features are in 2D vector form. The GTDB was ordered this way because our division of responsibilities between IST and BBN included BBN supporting vector format import of MultiGen data into the S1000 system. They have completed the MultiGen import to S1000 (as previously reported) for polygonal terrain and culture, but not for vector culture. Therefore, complex custom software (to expand and plant culture) would have to be used to convert the GTDB into a format acceptable for S1000.

IST has not yet received the second GTDB distribution with fragmented culture from Project 2851. We are currently looking at an ADDWAMS format culture import for the GTDB vector data into S1000.

PRC Lessons Learned Document: A review was performed, at STRICOM's request, of the lessons learned document produced by PRC after the P2851 SIF Hunter Liggett gaming area was used for the InterOperability Demonstration at I/ITSEC 1992.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 JAN 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$342,136.00	$95,795.23	$246,340.77	$0.00	$344.08	$0.00	$344.08	$0.00
TRAVEL	$15,122.02	$3,749.90	$11,372.12	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$83,297.96	$14,414.07	$25,685.89	$43,198.00	$59.56	$0.00	$59.56	$0.00
INDIRECT COSTS	$181,888.82	$53,025.47	$128,863.35	$0.00	$169.53	$0.00	$169.53	$0.00
TOTAL EXPENDITURES	$622,444.80	$166,984.67	$412,262.13	$43,198.00	$573.17	$0.00	$573.17	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	14,705.75	19,893.00
CURRENT HOURS			
CORTES	0.00	2.50	
HORAN	0.00	2.00	
PARRIES	0.00	19.00	
SMART	0.00	2.00	
TOTAL CURRENT HOURS	0.00	25.50	
CUMULATIVE HOURS THRU 1/14/93	5,187.25	14,731.25	19,918.50

FUNDED	$640,081.72
EXPENDED	$622,444.80
	$17,636.92

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 RESEARCH PARKWAY, SUITE 300, ORLANDO, FLORIDA 32826 (407) 658-5000

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: February 9, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the January 1993 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes
Visual Systems Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

April 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on April 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB:

Updated parameters for the GTDB requesting polygonalization and fragmented culture were given to PRC (the Project 2851 contractor). IST received verbal confirmation that two different GTDBs were contstructed of the downtown Ft. Irwin area. The gaming area used did not have model references, but does have road and cultural feature outlines. IST is expecting to recieve the GTDB distributions during the month of May and continue the processing for the SIMNET system.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 APR 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$347,278.01	$95,795.23	$251,482.78	$0.00	$1,209.42	$0.00	$1,209.42	$0.00
TRAVEL	$15,661.34	$3,749.90	$11,911.44	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$83,743.39	$14,414.07	$26,131.32	$43,198.00	$70.44	$0.00	$70.44	$0.00
INDIRECT COSTS	$184,462.06	$53,025.47	$131,436.59	$0.00	$537.55	$0.00	$537.55	$0.00
TOTAL EXPENDITURES	$631,144.80	$166,984.67	$420,962.13	$43,198.00	$1,817.41	$0.00	$1,817.41	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	15,008.75	20,196.00
CURRENT HOURS			
CORTES	0.00	5.00	
DAYAN	0.00	20.00	
HOWELLS	0.00	1.00	
LISLE	0.00	4.00	
MARROU	0.00	0.00	
PARRIES	0.00	33.25	
SMART	0.00	12.00	
TOTAL CURRENT HOURS	0.00	75.25	
CUMULATIVE HOURS THRU 4/22/93	5,187.25	15,084.00	20,271.25

FUNDED	$640,081.72
EXPENDED	$631,144.80
BALANCE	$8,936.92

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 Research Parkway, Suite 300 ORLANDO, FLORIDA 32826

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: May 14, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the April 1993 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes

Art Cortes
Visual Systems Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

February 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on February 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Contract Extension:

IST requested a contract extension during the month of February because of the late delivery of the GTDB database from the P2851 contractor. The extension was granted by STRICOM.

BDS-D Database Development Meeting:

Curtis Lisle and Art Cortes joined officials from US Army STRICOM, US Army TEC, Air Force ASD (P2851), PRC, and KOAN Corp. in a Army database policy meeting. During this meeting, policy was crafted for the production and validation of several visual databases created for the BDS-D program.

Ft. Irwin GTDB:

IST has not yet received the second GTDB distribution with fragmented culture from Project 2851. Curtis Lisle discussed the status of that database with Jim Sargent of PRC and Major Johnson of Air Force/ASD (director of P2851) at the BDS-D Database Development meeting. Both were helpful and pledged that the database would be made available. Adequate time is now available in the contract for the remaining database processing.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 28 FEB 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$344,297.44	$95,795.23	$248,502.21	$0.00	$2,161.44	$0.00	$2,161.44	$0.00
TRAVEL	$15,122.02	$3,749.90	$11,372.12	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$83,609.53	$14,414.07	$25,997.46	$43,198.00	$311.57	$0.00	$311.57	$0.00
INDIRECT COSTS	$182,927.48	$53,025.47	$129,902.01	$0.00	$1,038.66	$0.00	$1,038.66	$0.00
TOTAL EXPENDITURES	$625,956.47	$166,984.67	$415,773.80	$43,198.00	$3,511.67	$0.00	$3,511.67	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	14,731.25	19,918.50
CURRENT HOURS			
ABEL	0.00	2.00	
CORTES	0.00	4.00	
LISLE	0.00	21.00	
MARROU	0.00	39.00	
PARRIES	0.00	57.00	
PETTY	0.00	1.00	
SMART	0.00	16.00	
TUGGLE	0.00	23.00	
TOTAL CURRENT HOURS	0.00	163.00	
CUMULATIVE HOURS THRU 2/25/93	5,187.25	14,894.25	20,081.50

FUNDED	$640,081.72
EXPENDED	$625,956.47
BALANCE	$14,125.25

UNIVERSITY OF CENTRAL FLORIDA

INSTITUTE FOR SIMULATION AND TRAINING

12424 Research Parkway, Suite 300 ORLANDO, FLORIDA 32826

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: March 17, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the February 1993 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes
Visual Systems Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

May 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on May 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB:

The GTDB distribution expected from PRC did not arrive during May as expected. IST has made a request to get the distribution from PRC as soon as possible to allow sufficient processing time once the GTDB is received. Two different databases were generated over the same gaming area with different polygonal resolutions as a comparison experiment.

Equipment:

RAM memory expansion for a workstation used to support the database conversion will be ordered during the next month. The original request for this expansion was sent via contract letter on May 28, 1992.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 MAY 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$347,843.45	$95,795.23	$252,048.22	$0.00	$565.44	$0.00	$565.44	$0.00
TRAVEL	$15,796.34	$3,749.90	$12,046.44	$0.00	$135.00	$0.00	$135.00	$0.00
OTHER DIRECT COSTS	$83,763.45	$14,414.07	$26,151.38	$43,198.00	$20.06	$0.00	$20.06	$0.00
INDIRECT COSTS	$184,764.67	$53,025.47	$131,739.20	$0.00	$302.61	$0.00	$302.61	$0.00
TOTAL EXPENDITURES	$632,167.91	$166,984.67	$421,985.24	$43,198.00	$1,023.11	$0.00	$1,023.11	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED PREVIOUS REPORT	5,187.25	15,084.00	20,271.25
CURRENT HOURS			
CORTES	0.00	6.00	
DAYAN	0.00	0.00	
HOWELLS	0.00	0.00	
LISLE	0.00	1.00	
MARROU	0.00	0.00	
PARRIES	0.00	0.00	
SMART	0.00	8.00	
TOTAL CURRENT HOURS	0.00	15.00	
CUMULATIVE HOURS THRU 5/20/93	5,187.25	15,099.00	20,286.25

FUNDED	$640,081.72
EXPENDED	$632,167.91
BALANCE	$7,913.81

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 Research Parkway, Suite 300 ORLANDO, FLORIDA 32826

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL B001)

Enclosure: Cost and Progress Reports for Visual Database

Date: June 15, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the May 1993 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes

Art Cortes
Visual Systems Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042 (B001)

BAA 89-01

This contract is broken down into two tasks as described below. The Cost Report contains both tasks by current and cumulative cost. The Progress Report addresses Task 2.

- TASK 1: Rapid Production of Geospecific Databases
- TASK 2: Production of Standard Simulation databases for Multiple Image Generators

Cost and Progress Reports

June 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on June 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB:

Two GTDB databases polygonized at different resolutions were received from Project 2851. The databases had been expected for several months. Processing of these databases will occur during July and August.

Image Trip:

Curt Lisle attended a meeting of the Special Interest Group on Simulator Networking at Tucson, Arizona in coordination with the 1993 meeting of the Image Society. A trip report is attached.

Problems: None at this time

Trip Report
Image Society Meeting
June 22-24, 1993

Curtis Lisle, IST/VSL

Purpose: The purpose of this trip was to attend the Image Society meeting in Tucson, AZ. I attended the Networked Simulation Special Interest Grouped (SIGNET) headed by Mike Severding (ARINC). Several of the important people in Visual System Databases were at this particular conference in one of the special interest groups.

SIGNET meeting

SIGNET purpose : The SIGNET goal is to try to balance issues across core technology (DB, IG, display, perception & human factors). How does networking interact with these core technologies? Stay away from protocols and standard establishment, but study the impact of protocols & standards.

Attendees of SIGNET:

Dr. Hoock (ARL) is working with the TEC group on atmospheric models. He said there was some near-real time models running. He gave me the paper "Statistical Texturing Applied to battlefield-induced Clouds". Looks very promising.

Bruce Montag - SW Research Institute. (San Antonio, TX?) WST. (weapons system trainer) F-16 simulators & lantern version. Adding gridded field meteorological data sets into simulators. Sensor simulation coordinated with visual! DIS atmosphere subgroup meeting at his institute next month! Digital meteorological source for atmosphere. Source is reformatted for real-time use. Jim Bassinger aware of this. DMSO heard his presentation & liked it.

Gary ?? - STRICOM. Operational pilot in the Army. command positions. Moved to acquisition at STRICOM. Was at ARI (Orlando), two years ago, assigned to monitor flight simulators & ground simulators. Limited networking knowledge, but senses the move to this area. Mentioned Louisiana Maneuvers.

Judith Pafford- Hughes moved from database into program management over "visual new business". Hughes bought Rediffusion. Systems integrators; don't build their own IGs anymore. DIS involvement from Hughes

Pam Woodard - STRICOM for 3 weeks. Working on the "Which simulators can train which tasks? What level of correlation is needed?" work she wrote about will be continued with STRICOM.

Major George ???- helicopter pilot using scramnet at Kirtland AFB. Trying to study the technology and build in-house network simulators. Works for Lt. Colonel Reeves whose presentation is discussed later in this report.

Pam Whitter - Visual Systems at MDHC. Was involved when MDHC was alone in their state-of-the-art work. Now building a simulator using SGI GL programming directly in C.

Mike Panzitta - (E&S) IG database software. A senior project engineer on the CCTT program.

Dr. Economy - (Martin Marietta) looking at networked simulation for many different purposes. If your simulator can't network, then you won't sell. Also addressing low-cost simulators. Delivered product to SEGA already!

Jim Basinger - AF training. Heads technology development at Wright Patterson (not quite right). Maybe Looking at space training, too. Sponsors technology development. UTSS involvement. Be aware of technology & funnel the technology into the acquisition program for the AF.

Mike Severding - Was a pilot in the AF. Worked in the AF's simulator certification programs. Worked at Wright Patterson. ASD/YW (now YT) as a program manager. Set up beginnings of P2851 and UTSS.

John Coffee - GPS technologies. Not a network person. Media specialist. Translate technology so that leadership in the Navy can understand it and make good decisions.

Mike Sarsovich (sp?) - Naval Air Systems (?) Training. Gatekeeper in the networking issues. Sensitive to the Navy's needs. It is his responsibility to define the Navy's needs for networking. Creating an official position statement for the Navy. Must make sure the training is useful for the fleet. He said some of the trainers the Navy bought weren't used fully (all new technology may not be useful). Insure that the Navy is going the right way. UTSS program. He is doing a "selling program" to the fleet right now. The Navy leaders sold to congress that they don't need new resources to enter simulation. This was a mistake because Navy simulator resources are now overcommitted.

Tom Bohman - SYSTRAN (Scramnet) which is a high-speed networking layer. He has marketed the simulation industry. Also used within a simulator (host to IG, etc.). Where can networking be used?

Dr. Hoock - ARL (was Atmospheric sciences laboratory) trying to get weather & atmospheric effects. Zero to 300m elevation is the most imporant. Wind & terrain coupling. Fidelity on smoke plumes vs. capability.

Lt. Col Ed Reeves

AT Kirtland, hi-fi simulators, database generation capability. Combat training has always been a group activity since the caveman. Warfare is a group activity. "Joint warfare" is buzzword in the forces right now. The Colonel has been responsible for much of the progress of the lab at Kirtland.

training observation center - six role playing stations, forty watchers. Audio is their biggest problem when trying to do coordinated exercise. Tremendous problems as you go over wide area networks (transport delays). Based on Mult-Sim experiments at Ft. Rutger. The Army papers written in 88 and 89 helped him. They support SOF and search & rescue training. Using the room: class in training is on the 6 role-playing stations, beginning classes watch the

advanced ones under training. All video is recorded and timestamped. Fulcrum digital map system is used to locate all simulators Instructer has "John Madden" capability (can draw over the graphics on the screen during after-action review. Rader. NVG, FLIR (forward looking infared) supported on the weapons systems. Correlation needed for 8 channel display, GPS/Doppler/Inertial navigation using all these sensors! Multi-sensory correlation.

** you must solve the correlation problem on a non-networked system before attempting networking!

German Toronodo program used least-common-denominator. The visual system database polygons were converted & installed in DRLMS to get correlation. The Col. has lawn furniture in the MH-53J weapons system because lawn furniture hits rotor blades when the helicopter flies too close. If you choose the least common denominator, then you are not a weapons system trainer (WST), you are just an operational simulator.

** source data is very important. "Smart net" data network supports everything by connecting the DBGS systems and the engineers fixing the flight models (on suns) together. Software moves transparently across the stations. Multiple levels of security must work simultaneously on the network. FDDI and security switches used.

Jim Bassinger's talk:

SNAP - Simulation Network Analysis Project. Involves Pax River. Idea is to build a capability to test the timing of a single simulator, networked simlators, or an end-to-end test of a full system. Tie into a variety of places into the simulator ("When did the display actually change") , "when did the data actually come out on the network"). Timestamps are added to all states as they are recorded. Timestamps are based on timing signals from the GPS satellites. All hardware is currently in-place, software integration in process. Hope for some demonstration by Fall 93. GPS believed to be accurate to the microseconds granularity. Only a couple thousand dollars if you just want to get timestamps from GPS. You put a satellite antenna on your roof.

** GPS could be a good way to get absolute time for DIS simulators.

SNAP records analog signals or digital data (read off computer busses, or at an output port fired by a flag from the simulation software). The simulator would be in a special testing mode, not in general training mode. It is supposed that the time delays in the SNAP system itself have been considered. Data analysis provided for post-processing. This seems like a very experimental program. I wonder if it will be prove useful. No plans for incorporating this against flight crews yet. They are planning to deliver this to SOFATS for use to evaluate SOF's systems. Want to use SNAP with WarBreaker phase 2. Contact for SNAP is Ron Ewart, WL/FIGD, Wright-Patterson, (513) 255-4690. The system is designed to be transportable (two people carrying it). Maybe the DIS testbed should get one of these as an ultimate datalogger?

phase 1: local simulator. stick to visual system, stick to host.
phase 2: pax river involved. sim#1 to sim#2 perception time. delay as a function of network load measurements.

Bruce Montalk, SouthWest Research Institute:

Gridded field weather database which can support the environmental effects to distributed IGs, DRLMs, and host. Correlation is assured by being generated in a single place (not really, but a single source helps).

Prototyped on SGI Crimson Reality Engine. NightHawk doing 6-DOF (forces on airframe) and SGI RE (visual display). Model National Center of Atmospheric Research. JAWS (Joint Airport Weather ?) database used. Gridded field. Each node has temperature, pressure, wind velocity vector, moisture content. Very large storage. Today each simulator is using their own database. Using 200 meter source data, resampled to 400 meter spacing for use. Temporal updates are done at a 2 minute interval. Mark IVB takes DMSP data and produces grid field databases. 800nm x 800nm into 2048 points in each of 15 layers. DMSP is a satellite which is taking real time weather information (meteorilogical data). Underlying accurate basis for effects. DMSP updates slowly. Doppler position is updated every 2 minutes. ETAC (envin. tech. applic. center in AF) they take satellite data and extrapolate into the gridded field data used for their prototype. Mobile systems can do conversion within an hour. Idea is not to get exact data, but to have "representative" weather.

Planning to merge vector data into the gridded field representation.

The output of database processing is an abstract geometry representation sent to the IG (higher than polygons). Requires the IG to have an integrated scene management allocating polygons for different features. THIS IS DONE AT EACH SIMULATOR.
"ASEL range format". Environmental PDU planned here. Focus of architecture to maintain and work with the GF (gridded field) datatype.

600 weather parcels / field of view / frame rate in prototype system. WEST server? Temporal interpolation is quite a problem. The prototype doesn't do temporal interpolation; the weather is snapshotted at a single instant in time.

Bruce is in contact with the NRL Monterey group which is meeting for EEDIS (Environmental Effects in DIS) with USA CERL in Wash. DC July 1 and 2. Bruce used their source database.

SIGNET/CIGSIG joint meeting:

fading function discussion. Mike Severding raised the issue that most vendors used fading functions based on a single formula, but had customized it for their implementation. Could some standardization be found? Could IG vendor representatives find out how much they can talk about without violating their proprietary rights? Vendors agreed to cooperate.

Ron Matusof (CAE Link):

Very direct presentation about the major problems which must be overcome in networked simulation. Slide showing the intervisibility problem. Slide showing you can't navigate in one coordinate system and just convert your

coordinates when indicating your position (you will not be traveling the same amount of distance). The math derivation which Mike faxed earlier to IST covers this. Time delay on the network will become a serious problem, especially as we move to Wide Area networks with greater delays.

Dr. Economy, Martin Marietta:

Computations must be done for texture on both visibile and invisible objects. (i.e. tree, smoke, and building behind). Dumb depth buffers don't know to stop when the pixel is full. A smart Z-buffer can be difficult depending on the IG architecture.

** IGs can't interoperate if they have different pixel visit capacities because they will degrade differently. Also imperoperability problems because some may share frame 2, some may not (different degradation again).

Regular vs. irregular triangle polygonization will cause disagreements (i.e. water profile will be different because of the constraints of regular triangles). Problem is worse because the lake will get elevation (from underlying ground) -- the water flowing uphill problem.

Correct terrain LOD should keep the average density per vertical angle constant. He is arguing that terrain blending doesn't work becase of the terrain-following problem during the blending range. Mission critical features could be weighted so they blend down less drastically.

Load management is hard enough in a standalone IG. Load managment becomes a real problem in a networked simulation.

** picture of two simulations where the fade LOD has violated the fair fight. Problem because tanks blend out later than trees (mission critical problems). In a multi-LOD terrain system, models may be sitting on different terrain LODs than what is being displayed by any watching simulator's IG.

Load managment has a direct impact on interoperability.

Mission functions are embedded in the image generator (because the host couldn't do them -- too much computation), as the number of models increases, this load will increase (from todays 40% of load). Harder as weather models are added.

Dynamic terrain and dynamic environment effects the performance of mission functions. Must start simulating the physics of the 3D environment. *Rendering will shrink as a portion of the problem. Mission functions will dominate the cost of IGs..* Mission function ASICs?

Shadows - some limited dynamic shadows can be done, but this is special effects. True shadowing is not ready yet. Only "first level" shadows work. NVG uses the shadows. Transitioning between shadow sets. C-130 uses an IR spotlight at night and needs shadows for detecting where the target is.

** database will be more closely-coupled with the IG in the future.

ATM: small packets with 600 Megabits / second throughput. Adjust wordlength (Asynchronous transfer medium??) works through twisted pairs. For sale today. Any size packets? Very fast hardware to sense gaps in the network. EE times has ads for it. If this is true, it could revolutionize network.

Tom Bohman, SYSTRAN:

SCRAMNET is used on a lot of simulation systems. SCRAMNET supports replicated shared memory between portions of a distributed real-time system. Memory connection is established between the CPUs. Whenever any computer changes a value in any global memory location, the SCRAMNET boards communicate with zero bus bandwidth in the host. transport delays between 2 and 4 microseconds. This only works for local areas. It can be extended up to about 25 kilometers. 150 Mbits/sec, 65Mbyte/sec.

Wide area networks are a problem. DIS requires addressing WAN (for example, satellite). Shared memory doesn't work here because of transport delays.

Univ. of Illinois, The Cave, uses SCRAMNET to connect the four different IGs together on the four sides of the cube. The IGs are GenLocked together so their right and left eyes are coordinated. All users are wearing LCD shuttered glasses. Control data was transmitted using SCRAMNET. "swapbuffers" had to be done at same time on all IGs (within a few microseconds).

Throughput, transport delay, determinism, payload size per packet, CPU overhead, scalability, how many different CPU types, synchronization capabilities. All these are measures of merit. How do we prioritize this list for individual tasks.

Future capability: Current version of scramnet still available for lower cost in five years. > 100 MByte/second throughput available. Mapping function so that all global data doesn't have to be sent (didn't understand this). Memory mapped interrupts & triggers already exists, it may be improved. Triggers can be generated due to changes on a particular memory location.

ATM: 63 byte packets and it is a wide-area network. It is a protocol which sits upon lower protocols. Packet switched approach. He believes that there is "more work to be done" with ATM before it is a solid, reliable network substrate.

General discussion of interest to DT:

Environment server - in DIS there is not a server. DIS's basic rules prohibit the server. There is no central information repository. Several members believe the "no central repository" idea is going to go away or have allowed exceptions. Atmospheric & weather effects will force this to change - it would make more sense. Vote was for a DT server to handle the ground changes. The opinions I solicited on the "need to know" property for the DTSU were all in favor of removing that requirement (simulators decide to keep it or throw it away). Positive feedback from Ron (CAE) about the distinction between "in-process" pdus and "final shape" PDUs for a certain feature. This way, some simulators can ignore "in process" DT features but merge them into the database when they reach their final form.

SIGNET only meeting

Anti-aliasing issues: A new vendor (Tulorian?) has a non-antialiased system with high capacitiy for a low price (8k polygon system for $48k). This has effective price/performance, therefore it will have some systems fielded with it. Dr. E said that their low-performance (no anti-A) has bad dissolve into the distance. It can actually give you bad queues. You keep your eyes focused in closer. Ron (CAE) was at Atari and he said that you had bad queues.

CCTT has stringent anti-aliasing requirements. If they play against non-antialiased systems, the "Kell" factor will be wiped out. Dr. E presented the problem of vertical bands alternating black and white. As you back away, that feature will become all white or all black and will scintillate between the two. MTF was used as a measure.

*** problem to determine/specify the "performance characteristics" of a system without forcing a particular design (especially in Government RFPs). For example, say "good enough" anti-aliasing not "4x4 subpixel smoothing". We didn't reach a conclusion on how to address this problem. Texture anti-aliasing is amore critical problem because polygon interiors cover larger screen area (more pixels) than the edges. Edge smoothing usually defeats sensors because the target is smooth and the background has crawling texture.

Texture will continue to be in the IGs of the future. Prediction of increased use and capability. Martin's SEGA system had texture anti-aliasing but didn't have edge anti-aliasing. Even when they could offer $20 more for edge anti-aliasing, SEGA didn't want the extra cost.

Action: Raise question with the DIS group at IST whether IST can propose an anti-aliasing experiment. Texture and edge smoothing vs. some particular scenarios. Try to figure out how to make it relevant to RFPs and trainer capability.

opinion: Caligraphics are losing market share. They will continue, but the amount of market requiring them will shrink. Needed for Navy landing on ships or short runways. Higher resolution raster can replace calligraphics in some applications (more as resolution increases). Use a "Snelling factor" (eye chart) to determine overall system viewpoint. This visual acuity requirement could be specified at a different level by each customer.

Handicapping: Dr.E raised the issue some simulators being handicapped to try to compensate for the visual anomalies in IGs. This opens up a dangerous potential for negative training. DIS approach currently is that DIS will not correct for unequal IGs. Drastically different simulators shouldn't be allowed to apply. The Colonel said that we need to educate the senior leaders about the problems or they will have unrealistic expectations. View that there are too many variables buried into this problem. Handicapping must be done by adjusting some system parameter (size of target, visual range, anti-aliasing, etc.). Requires mapping of system "adjustments" to the desired handicap! (must be developed, yet).

** given enough data (after several years of operational use?), controlled handicapping seems to have some use.

DIS compliance: Must be refined more to be useful. We don't know what "DIS compiant" means - no definition has been made. A better question is "must be interoperable". Ron (CAE) said that several good people are analyzing this problem to determine levels of compliance or levels of capability needed. May take several years before a good answer is ready, though.

Gamma correction: measure at the displays. It doesn't matter where its done. CIE color matching must be done at the output. Need to measure at multiple brightnesses.

Celeste Howard: offered 1931 CIE metrics for color definitions for measuring consistencies. Get away from RGB (not perceived in the eye this way). IF everybody is consistent in CIE space, then we are comparing contrast and luminance values. She is preparing a color proposal for common objects (trees, color, sky, etc.). Need equipment for measuring color coordinates or radiometric values (Minolta makes one of these). Dr. Economy brought up that gamma correction is required to prevent hue shifting as the display device intensity is changed. Dr. E believes that CIE values cannot replace gamma correction because of this problem. Old AVTS system (GE) doesn't have gamma correction to match the current CompuScene series. In Celeste's approach, a separate lookup table is developed for each display device on the IG. *Interoperability is assured by exchanging CIE values for features in the database, not RGB (which requires gamma tweaking of display devices).*

Gamma correction definition - A function to keep each color gun's perceived intensity consistent as brightnesses is changed. No hue shifts occur. (Dr. Economy).

The group decided that Celeste's approach should be adopted. Requirements should be made in CIE measurements off the display systems.

IGs working in CIE space: Question raised about image generators using CIE internally and converting to RGB on output only. Dr. Economy mentioned that PT-2000 used YIQ internally for some operations and said that a matrix multiplication would be added on the output to convert from YIQ to RGB. Discussion of multipliers vs. color lookup table to do this conversion. Color table would be very large.

Recommendations by SIGNET to the whole group:

1. DIS should recommend standard CIE values for certain colors. Don't tweak your display. Color of interchanged objects will be represented in CIE space.

2. P2851 should output databases in CIE values. SIF supports HSV and RGB outputs today. Celeste didn't like HSV. She said it was old and obsolete.

Joint meeting on 6/24/93

• presentation by Kirtland AFB Colonel. They have spent a lot of time and energy to create a sophisticated DB generation capability using Martin Marietta's TARGET. Developed several large, government owned databases. Releasing these as SIF to P2851. Source data fusion and registration of multiple

sources had to be tracked carefully. They are interoperating between several high-fidelity simulators using their own networking implementation.

** DIS design team should connect with networking people at Kirtland in order to get lessons learned. Particularly networking of control info (radio, audio, etc.). Look at AF's exercise control protocol and compare/constrast with new 2.0 PDUs for exercise control.

MD training systems presentation:

definition of correlation - correlation is a measurable correspondence among sensor/visual CIG outputs , simulated systems outputs, and the real world.

Level of fidelity is an important simulator measure which must be taken into account (picture comparing two cartoon scenes where objects were moved or missing).

Sensor types - visual OTW, nav FLir, tgt FLir, dig map, TC/TF display, flight control, radar, NVG, low-light TV sensors.

How do you observe the correlation?:: correspondence, recognition of things, location & size of things, perspective & aspect of models, time synchronization of moving models.

Level of detail correlation must be addressed by the DB generation and the simulator must fade/swap LODs in a known way.

polygon vs. gridded - Radar is usually high density gridded. If the source database was polygonal, you get harsh, artificial polygon-shaped shadows. Radar imagery looks like low sun-angle shaded terrain B&W profiles. Since the profile is the most important thing, high density is a driving requirement.

1st step of correlation - provie corrrespondence among entitties, objects represented by the outputs of high-performance simulators on DIS network. Then go to lower-fidelity after that.

Future vision: direct conversion of live imagery from sensors driving the simulators. Database production problem will go away, but in the meantime...databases should be constructed from fused source imagery.

Minimize the modeling steps. Model only what you MUST model, but your development cost will go up. He showed a picture of three-band, interactive (pseudo realtime) feature classification from LandSat/SPOT imagery. Supervised classification algorithm was used. Reached 85% classification accuracy. Neural network algorithm used.

** *issue raised:* standardized outputs which can be measured against to verify that a simulator database is "verified" could be agreed upon. This concept seems like the "right numbers coming out of the metric suite which was run"...

compared - texture height, features height, etc... (missed rest of the list). Implemented a 14kilo x 14kilo database on the Vidal-7 IG (textured).

Results were presented, but the scale of the results was not explained. The results have been returned to P2851 in their final report.

Recommendations:

• implement a common DIS environemt database for all simulators. (use SIF/HDI).

• Agree on correlation definition & specification for simulators.
• Develop quantitative, automated, and rapide correlation testing tools from common and CIG databases (elevations, features, models, texture).
• drive database/CIG developments by correlation performance.

SIGNET Action-item suggestions:

SIG members provide ideas on correlation development. Definition, metrics, and survey the sate-of-the art.

• Make a Benchmark database for minimum aceptable IG performance to be provided. DIS performance specification. If we are measuring with real vehicles in the real world (via GPS), then the benchmark must be the real world! Issue raised that this wouldn't work for all-one-IG network. Seemed like only the DB group liked this. Dr. E suggested that SIMNET was an example of this already and the "all same database" didn't help any in terms of reaching correlation in a heterogeneous network. It seems that there may be use for a "benchmark database", but we didn't reach a final conclusion here.

• On-line DB generation/transformation. Provide a parametrized (GTDB or SIF) DB which can be used/queried. (this wasn't mentioned).

Really fast DT presentation:

Curt gave a ten minute talk on the DT program, the basic architecture, and the lessons we were expecting to learn from the prototype. Explained that results would be presented at the DIS conferences. No time was available for questions.

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 30 JUNE 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$349,021.40	$95,795.23	$253,226.17	$0.00	$1,177.95	$0.00	$1,177.95	$0.00
TRAVEL	$15,900.95	$3,749.90	$12,151.05	$0.00	$104.61	$0.00	$104.61	$0.00
OTHER DIRECT COSTS	$83,881.96	$14,414.07	$26,269.89	$43,198.00	$118.51	$0.00	$118.51	$0.00
INDIRECT COSTS	$185,353.12	$53,025.47	$132,327.65	$0.00	$588.45	$0.00	$588.45	$0.00
TOTAL EXPENDITURES	$634,157.43	$166,984.67	$423,974.76	$43,198.00	$1,989.52	$0.00	$1,989.52	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	15,099.00	20,286.25
CURRENT HOURS			
CORTES	0.00	8.00	
DAYAN	0.00	7.00	
LISLE	0.00	6.00	
FU	0.00	72.00	
CURRENT HOURS 5/21-6/17/93	0.00	93.00	
CUMULATIVE HOURS	5,187.25	15,192.00	20,379.25

FUNDED	$640,081.72
EXPENDED	$634,157.43
BALANCE	$5,924.29

UNIVERSITY OF CENTRAL FLORIDA
INSTITUTE FOR SIMULATION AND TRAINING
12424 Research Parkway, Suite 300 ORLANDO, FLORIDA 32826

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention: Mr. Raymond F. Green AMSTI-EC

Subject: BAA 89-01 Monthly Progress, Status and Management Report

Reference: Contract N61339-90-C-0042 (CDRL C001)

Enclosure: Cost and Progress Reports for Visual Database

Date: July 19, 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for Task 2 for the June 1993 time period are fowarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes

Art Cortes
Visual Systems Manager

PREPARED FOR:

STRICOM
12350 RESEARCH PARKWAY
ORLANDO, FL 32826

CONTRACT N61339-90-C-0042

COST AND PROGRESS REPORTS

FOR

JULY 1993

PREPARED BY:

INSTITUTE FOR SIMULATION AND TRAINING
UNIVERSITY OF CENTRAL FLORIDA
12424 RESEARCH PARKWAY
ORLANDO, FL 32826

Progress Report
Project 2851 GTDB/SIF Processing

Curtis Lisle
Visual Systems Lab/IST

Report on July 1993 Activities

This report summarizes the progress on the ECP to the MIDB project. The extension to the MIDB project was made for the purpose of processing a single GTDB and a single SIF database for display on the SIMNET IG.

Ft. Irwin GTDB:

Two GTDB databases polygonized at different resolutions were received from Project 2851. The databases had been expected for several months. Processing of these databases will occur during July and August.

The databases have been read by the IST-written GTDB-to-MultiGen converter. The gaming area datasets have been converted to MultiGen polygonal format at the time of this report. Further processing into the run-time format for the SIMNET IG is continuing into August.

We are planning to complete the conversion, the documentation of the conversion effort, and the software documentation as the last tasks on this contract.

Problems: None at this time

CONTRACT N61339-90-C-0042
RESEARCH & DEVELOPMENT FOR VISUAL DATABASE

COST REPORT FOR THE PERIOD ENDING 31 JULY 93

TASK 1 - RAPID PRODUCTION OF GEOSPECIFIC DATABASES
TASK 2 - PRODUCTION OF STANDARD SIMULATOR DATABASES FOR MULTIPLE IMAGE GENERATORS

	CUMULATIVE COST	TASK 1 CUMULATIVE COST	TASK 2 CUMULATIVE COST	EQUIPMENT	CURRENT COST	TASK 1 CURRENT COST	TASK 2 CURRENT COST	EQUIPMENT
LABOR	$351,606.27	$95,795.23	$255,811.04	$0.00	$2,584.87	$0.00	$2,584.87	$0.00
TRAVEL	$15,900.95	$3,749.90	$12,151.05	$0.00	$0.00	$0.00	$0.00	$0.00
OTHER DIRECT COSTS	$85,335.46	$14,414.07	$27,723.39	$43,198.00	$1,453.50	$0.00	$1,453.50	$0.00
INDIRECT COSTS	$187,048.62	$53,025.47	$134,023.15	$0.00	$1,695.50	$0.00	$1,695.50	$0.00
TOTAL EXPENDITURES	$639,891.30	$166,984.67	$429,708.63	$43,198.00	$5,733.87	$0.00	$5,733.87	$0.00

	TASK 1	TASK 2	CUMULATIVE HOURS
HOURS REPORTED			
PREVIOUS REPORT	5,187.25	15,192.00	20,379.25
CURRENT HOURS			
CORTES	0.00	2.00	
DAYAN	0.00	11.00	
HARDIS	0.00	3.50	
HOWELLS	0.00	1.00	
LISLE	0.00	24.00	
FU	0.00	80.00	
CURRENT HOURS 6/18-7/15/93	0.00	121.50	
CUMULATIVE HOURS	5,187.25	15,313.50	20,500.75

FUNDED	$640,081.72
EXPENDED	$639,891.30
BALANCE	$190.42

STRICOM
12350 Research Parkway
Orlando, FL 32826

Attention:	Mr. Ray Green
Subject:	Monthly Progress, Status and Management Report
Reference:	Contract N61339-90-C-0042
Enclosure:	Cost and Progress Reports for Visual Database
Date:	19 August 1993

Dear Mr. Green:

In accordance with the requirements of the above referenced contract, the Monthly Progress, Status and Management Report and Cost Report for the July 1993 time period are forwarded for your review and/or approval.

If you have any questions, please contact me at 658-5093.

Sincerely,

Art Cortes

Art Cortes
Visual Systems Manager